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Original article

Touch Imprint Cytology of Core Needle Biopsy Specimen, Integrated with Radiologic Assessment for Rapid Diagnosis of Breast Lesions: A Libyan Single-Center Experience

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Abstract
Rapid confirmation of breast lesion adequacy and likely malignancy during image-guided biopsy may shorten diagnostic delay. This study evaluated touch imprint cytology (TIC) prepared from core needle biopsy material and interpreted in conjunction with radiologic assessment. This retrospective single-center study analyzed 253 breast lesions sampled by core needle biopsy. Descriptive clinicoradiologic data were extracted from the archives of Alrazi University Hospitals (Alzuhor and Alhelal Abbad Hospitals). For diagnostic performance analysis, a composite histopathologic reference standard was constructed using excision histology when available and core biopsy histology otherwise. TIC results were dichotomized as malignant/suspicious versus benign for primary analysis, and sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated with 95% Wilson confidence intervals. The cohort included 253 patients (mean age 45.2 ± 11.6 years; median 45, IQR 38-50). Histopathologic outcome was classifiable in 147 lesions, of which 109 (74.1%) were malignant, and 38 (25.9%) were benign. Among 127 lesions with both a classifiable histopathologic outcome and interpretable TIC result, TIC showed sensitivity 83.9% (95% CI 75.1-90.0), specificity 97.1% (95% CI 85.1-99.5), PPV 98.7% (95% CI 93.2-99.8), NPV 68.8% (95% CI 54.7-80.1), and overall accuracy 87.4% (95% CI 80.5-92.1). Recorded imprint adequacy was high (210/213, 98.6%). Malignancy rates rose with increasing BI-RADS category, reaching 93.8% for BI-RADS 4C and 100% for BI-RADS 5 among lesions with paired histopathology. TIC of core needle biopsy specimens, when interpreted within a radiologic-pathologic framework, provided high specificity and very high PPV for rapid recognition of malignant breast lesions in this Libyan series. The technique appears particularly valuable as a pragmatic adjunct to standard core biopsy workflows where immediate histologic processing or frozen section support is limited.
Keywords. *Breast Lesion, Touch Imprint Cytology, Core Needle Biopsy, BI-RADS, Breast Pathology.*

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Introduction

Breast cancer remains the most commonly diagnosed cancer among women worldwide, and the burden is rising in many low- and middle-income regions, where delayed presentation and constrained diagnostic infrastructure can adversely affect outcomes [1,2]. Within contemporary breast practice, diagnosis is ideally established through triple assessment—clinical evaluation, imaging, and tissue sampling—because no single modality is sufficient in isolation for all lesions [3,4]. Core needle biopsy (CNB) has become the principal percutaneous method for tissue diagnosis because it preserves architecture, supports tumor typing and biomarker work-up, and generally outperforms cytology alone for definitive characterization of suspicious lesions [3,4,12].

Touch imprint cytology (TIC) of CNB material remains attractive because it can provide a rapid cytomorphologic impression while preserving the core for routine histology. The published literature on breast TIC consistently suggests that the method is most valuable as an adjunct rather than a substitute for histology. In classic work, Jacobs et al. demonstrated the feasibility of image-directed TIC [19], while Klevesath et al. reported its usefulness for immediate reporting of symptomatic lesions [13]. Masood et al. later showed high overall performance during image-guided biopsy, and Kehl et al. confirmed that TIC can support immediate diagnosis when specimen quality is adequate [14,15]. In a broader experience, Kubik et al. emphasized the value of imprint cytology for rapid categorical assessment during image-guided core biopsy [16], Schulz-Wendtland et al. documented favorable long-term follow-up in stereotactically sampled lesions [17], and the recent study by Boler et al. renewed interest in TIC as a practical form of rapid on-site evaluation (ROSE) in routine breast practice [18]. At the same time, the wider breast cytology literature has continued

to evolve. The International Academy of Cytology Yokohama System has helped standardize interpretation and communication in breast FNAC [5-10], and modern studies have shown that rapid on-site assessment can improve adequacy assessment and strengthen immediate triage. Wong et al. highlighted the operational value of ROSE in a dedicated breast setting [7], Torous et al. identified the main diagnostic pitfalls in rapid breast cytology—particularly low-cellularity, lobular, and fibroepithelial lesions [11]—and Philipo et al., as well as Kimambo et al., showed that rapid cytologic triage remains highly relevant in resource-constrained African settings [27,28]. In a recent review, Kim et al. argued that cytology still retains an important complementary role alongside CNB, especially when interpreted in a well-structured multidisciplinary workflow [31].

Equally important is radiologic-pathologic concordance. Several authors have underscored that even an apparently benign biopsy result cannot be accepted uncritically when imaging is suspicious. The College of American Pathologists Q-Probes study by Idowu et al. positioned radiologic-pathologic correlation as a core quality indicator in breast diagnosis [23]. Park et al. provided a practical framework for determining concordance and discordance after ultrasound-guided breast biopsy [24], while Mohan et al., Archana et al., and Ghunaim et al. each demonstrated the continuing value of correlating BI-RADS categorization with final pathology in routine practice [22,26,29]. More recently, Silva et al. and Sanderink et al. emphasized that the optimal biopsy pathway depends on lesion visibility, imaging modality, and local resources [30,32]. Against this background, the present study evaluates TIC of CNB specimens in a Libyan single-center cohort and specifically examines how rapid cytologic interpretation performs when integrated with radiologic assessment and final histopathology in a low-resource setting.

Methods

Study design and data source

This retrospective single-center study analyzed 253 breast lesions sampled by core needle biopsy. Descriptive clinicoradiologic data were extracted from the archives of Alrazi University Hospitals (Alzuhor and Alhelal Abbad Hospitals). For diagnostic performance analysis, a composite histopathologic reference standard was constructed using excision histology when available and core biopsy histology otherwise. TIC results were dichotomized as malignant/suspicious versus benign for primary analysis, and sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated with 95% Wilson confidence intervals.

Case selection

All lesions recorded in the dataset were retained for descriptive analysis. Diagnostic performance calculations were restricted to lesions with a classifiable histopathologic outcome (benign or malignant) and an interpretable TIC result. Cases recorded as non-diagnostic, missing, or otherwise uninterpretable for the relevant comparator were excluded from metric calculations but described separately.

Reference standard

Because excision histology was unavailable for many lesions, the primary reference standard was a composite histopathologic endpoint: final excision histology when present, otherwise core needle biopsy histology. This approach preserved the maximum analyzable sample while avoiding imputation of missing outcomes. A secondary descriptive comparison against final excision histology alone is reported in the results as a limited sensitivity analysis.

TIC and imaging classification

TIC entries were reviewed and harmonized into broad analytic groups. Cytology interpretations consistent with invasive carcinoma, ductal carcinoma in situ, lobular carcinoma, or other malignant descriptors were classified as malignant. Clearly benign entities, including fibroadenoma, fibrocystic change, duct ectasia, adenosis, mastitis, cystic and lipomatous lesions, were classified as benign. Cytology reported as suspicious was treated as test-positive in the primary analysis to reflect real-world escalation of care. Imaging impressions were similarly grouped as benign/probably benign versus suspicious/malignant, and BI-RADS values were normalized to categories 2, 3, 4, 4A, 4B, 4C, and 5.

Statistical analysis

Continuous variables are presented as mean ± standard deviation or median with interquartile range, as appropriate. Categorical variables are reported as frequency and percentage. Sensitivity, specificity, PPV, NPV, and overall accuracy

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were calculated from 2×2 contingency tables with 95% Wilson confidence intervals. The association between increasing BI-RADS category and malignant histopathology was explored descriptively and by Spearman correlation. The analysis was performed from the supplied spreadsheet without altering the source data.

Results

A total of 253 breast lesions were included. Patients were predominantly female, and their ages ranged from 13 to 80 years, with a mean of 45.2 ± 11.6 years. The highest case volume occurred in the 40–49-year age group. Lesions were slightly more frequent in the left breast (122) than the right (115), with 9 bilateral presentations recorded (Table 1 and Figure 1).

Table 1. Clinicodemographic characteristics

Variable	Value
Total cases	253
Female sex	247
Age, mean ± SD (years)	45.2 ± 11.6
Age, median (IQR)	45 (38-50)
Age range	13-80
Lesion side: left	122
Lesion side: right	115
Lesion side: bilateral	9

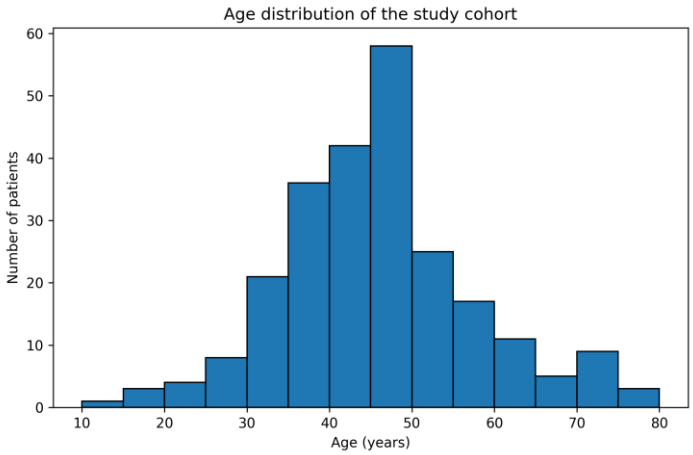

Figure 1. Age distribution of the study cohort

Imaging data showed substantial representation of suspicious and highly suspicious lesions. After normalization, BI-RADS 2 accounted for 91 cases, BI-RADS 3 for 18, BI-RADS 4 for 46, BI-RADS 4A for 4, BI-RADS 4B for 12, BI-RADS 4C for 18, and BI-RADS 5 for 53; BI-RADS was missing in 11 cases. Among lesions with paired BI-RADS and classifiable histopathology, the proportion of malignancy increased from 4.0% in BI-RADS 2 to 33.3% in BI-RADS 3, 83.9% in BI-RADS 4, 93.8% in BI-RADS 4C, and 100% in BI-RADS 5, demonstrating a strong monotonic correlation between radiologic suspicion and malignant outcome (Spearman rho 0.70, $p < 0.001$) (Table 2 and Figure 2). Although the BI-RADS 4A malignancy rate was 75.0% (3/4) in this dataset, this estimate should be interpreted cautiously because the subcategory included only four cases and is likely influenced by small-sample variation.

Table 2. Radiologic findings and BI-RADS distribution

Category	n	%
BI-RADS 2	91	36.0
BI-RADS 3	18	7.1
BI-RADS 4	46	18.2
BI-RADS 4A	4	1.6

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BI-RADS 4B	12	4.7
BI-RADS 4C	18	7.1
BI-RADS 5	53	20.9

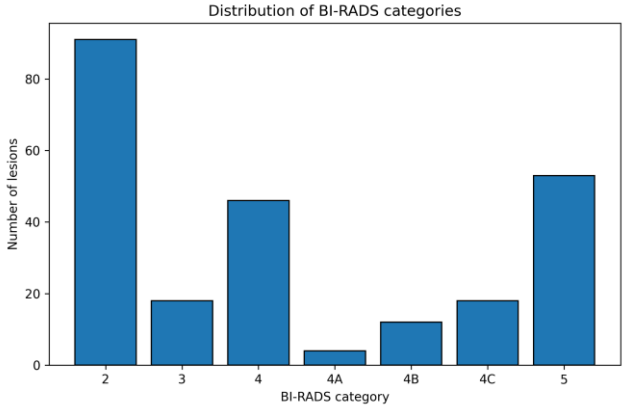

Figure 2. Distribution of BI-RADS categories after normalization of recorded imaging data

TIC interpretations were heterogeneous and included invasive ductal carcinoma, ductal carcinoma in situ, lobular carcinoma, fibroadenoma, fibrocystic change, benign breast tissue, adenosis, duct ectasia, inflammatory lesions, and a small number of non-diagnostic or suspicious smears. Adequacy was explicitly recorded in 213 cases; among these, 210 (98.6%) were judged adequate for interpretation. The composite histopathologic endpoint was classifiable in 147 lesions, comprising 109 malignant and 38 benign lesions. TIC was both interpretable and paired with histopathology in 127 lesions. On this basis, TIC yielded 78 true-positive, 33 true-negative, 1 false-positive, and 15 false-negative results. Accordingly, the specificity denominator was 34 benign lesions, comprising 33 true-negative cases and 1 false-positive case. The resulting sensitivity was 83.9% (95% CI 75.1-90.0), specificity 97.1% (95% CI 85.1-99.5), PPV 98.7% (95% CI 93.2-99.8), NPV 68.8% (95% CI 54.7-80.1), and overall accuracy 87.4% (95% CI 80.5-92.1) (Table 3, Table 4, Table 5 and Figure 3).

Table 3. Touch imprint cytology versus composite histopathologic outcome

Histopathologic outcome	Histopathology malignant	Histopathology benign
TIC positive (malignant/suspicious)	78	1
TIC negative (benign)	15	33

Table 4. Diagnostic performance of TIC

Metric	Estimate	95% CI	Denominator
Sensitivity	83.9%	75.1-90.0%	93
Specificity	97.1%	85.1-99.5%	34
PPV	98.7%	93.2-99.8%	79
NPV	68.8%	54.7-80.1%	48
Accuracy	87.4%	80.5-92.1%	127

Table 5. BI-RADS category versus malignant histopathology

BI-RADS	Benign	Malignant	Total	Malignancy rate
2	24	1	25	4.0%
3	6	3	9	33.3%
4	5	26	31	83.9%
4A	1	3	4	75.0%
4B	0	11	11	100.0%
4C	1	15	16	93.8%
5	0	48	48	100.0%

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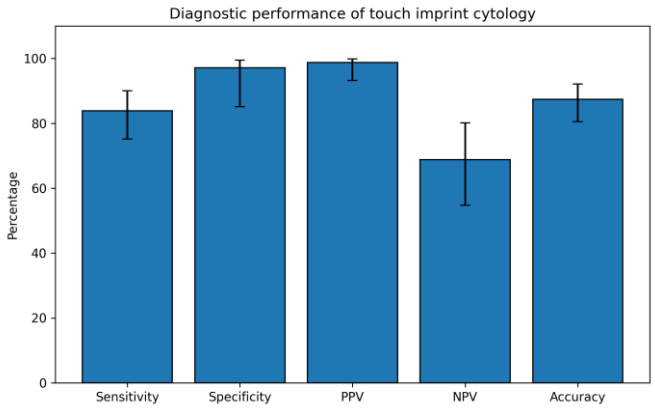

Figure 3. Diagnostic performance of touch imprint cytology with 95% confidence intervals.

False-negative TIC results were observed mainly in lesions ultimately diagnosed as invasive ductal carcinoma, lobular carcinoma, ductal carcinoma in situ, metaplastic carcinoma, or mixed invasive carcinoma but initially interpreted cytologically as adenosis, benign breast tissue, fibrocystic change, papilloma, or complex fibroadenoma. The single false-positive case was interpreted as invasive ductal carcinoma on imprint cytology but was categorized histologically as a benign phyllodes tumor. These discordances emphasize the known interpretive limitations of TIC in low-cellularity lesions, special histologic subtypes, and proliferative benign mimics. FNAC was available only in a small, selected subset and, therefore, was not suitable for a robust head-to-head comparison across the full cohort. In the limited analyzable subset with recorded FNAC and classifiable histopathology, all cases were malignant, preventing estimation of specificity. Accordingly, FNAC findings are presented descriptively rather than as a primary comparator.

Discussion

This study supports the view that TIC can function as a clinically useful rapid adjunct to image-guided breast CNB when interpreted within a radiologic-pathologic framework. The overall pattern in our dataset—a high specificity and positive predictive value with a more modest sensitivity—aligns with the established literature showing that TIC is strongest for rapidly confirming malignancy, but less reliable for confidently excluding it [13-19]. In practical terms, our findings place this Libyan series within the same broad performance envelope reported internationally, while also reflecting the realities of routine service delivery in a resource-constrained environment. The present sensitivity was lower than the near-ceiling values reported in some historical TIC series, but the direction of difference is clinically plausible. Masood et al. reported very high overall performance for imprint cytology during image-guided biopsy [14], Kehl et al. found TIC to be a valid immediate diagnostic option when sample quality was good [15], and Schulz-Wendtland et al. documented excellent long-term outcomes in a stereotactic cohort with concordant benign lesions [17]. In the more recent study by Boler et al., 37 of 43 malignant lesions and 35 of 36 benign or inflammatory lesions were correctly classified by TIC, again suggesting particularly strong specificity with some persistent false-negative risk [18]. Our somewhat lower sensitivity likely reflects real-world lesion heterogeneity, including low-cellularity lesions, in situ disease, and lobular or fibroepithelial patterns, all of which have been repeatedly identified as diagnostic problem areas in rapid breast cytology studies [11,15,31]. The high specificity observed in this study is particularly important clinically. A malignant or strongly suspicious TIC result in a radiologically suspicious lesion can accelerate counseling, multidisciplinary discussion, and downstream planning while final histology and biomarker work-up are pending. This interpretation is consistent with the long-standing rationale for same-day or one-stop diagnostic pathways. Bulte et al. showed that rapid cytologic assessment can deliver reliable provisional same-day results in breast clinics, especially for malignant lesions, and Mathieu et al. recently demonstrated that immediate diagnosis on CNB remains an active area of innovation even with newer optical technologies [33]. Our data therefore support the continued value of rapid preliminary diagnosis, provided that it is clearly framed as provisional and not a replacement for histologic confirmation. The study also reinforces the central importance of radiologic-pathologic concordance. In breast diagnostics, the meaning of a cytologic or histologic result depends on whether it adequately explains the imaging abnormality. Idowu et al. identified diagnostic correlation with breast imaging findings as a measurable quality issue across institutions [23], and Park et al. provided a practical framework for classifying concordant benign, discordant benign, borderline/high-risk, and malignant outcomes after biopsy [24].

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More recent observational studies by Mohan et al., Archana et al., and Ghunaim et al. likewise showed that BI-RADS subcategorization and post-biopsy concordance review materially influence the recognition of false-negative or underestimated lesions [22,26,29]. In our cohort, this principle is directly relevant to benign TIC results occurring in BI-RADS 4C or 5 lesions: such cases should be treated as potentially discordant until histology, repeat sampling, or multidisciplinary review resolves the discrepancy. These findings have particular relevance for low-resource health systems. In settings where frozen section, rapid cell-block processing, or advanced one-stop clinic infrastructure may not be routinely available, TIC offers a comparatively inexpensive and technically feasible means of obtaining immediate diagnostic information. Silva et al. highlighted that breast biopsy practice must be adapted to local capacity while maintaining diagnostic safety [30], and studies from Tanzania by Philipo et al. and Kimambo et al. demonstrated that rapid cytology-based triage can be implemented effectively in African settings with constrained pathology resources [27,28].

The present data extend that logic to Libya, where a rapid adjunct to CNB may help shorten uncertainty, strengthen same-visit decision-making, and improve the efficiency of referral pathways without requiring major additional infrastructure. Comparison with FNAC in the present dataset should remain cautious because FNAC data were available only for a limited subset. Nevertheless, the broader literature is informative. Meta-analytic and review data continue to show that CNB generally provides stronger architectural and biomarker information than FNAC for suspicious breast lesions [3,4], while the Yokohama-era literature indicates that standardized breast cytology retains value for triage, rapid assessment, and selected clinical scenarios [5-10,31]. Accordingly, TIC and FNAC should be viewed less as competing stand-alone tests and more as parts of a layered diagnostic strategy in which imaging, cytology, and histology each answer slightly different clinical questions. From a regional and international perspective, the principal contribution of this study is that it adds evidence from a setting that is underrepresented in the breast cytology literature. Most published TIC data come from Europe, North America, or South Asia [13-19], and very few reports have described the integration of TIC, CNB, and imaging within North African practice. By showing that the test characteristics of TIC in Libya are broadly comparable to those reported elsewhere—while also documenting the importance of radiologic-pathologic correlation—this study helps contextualize how rapid breast diagnostic workflows might be adapted for countries where delays in pathology reporting or access to subspecialty services remain important barriers.

Strengths and Limitations

The main strength of this study is the use of a real-world dataset reflecting routine breast diagnostic practice in a resource-constrained environment. The series also allowed simultaneous examination of cytology, imaging, and histopathology rather than isolated test performance. Several limitations should be acknowledged. First, the data were retrospective and dependent on the completeness and internal consistency of spreadsheet documentation. Second, final excision histology was unavailable for most lesions, so the primary endpoint used a composite histopathologic standard combining excision and core biopsy diagnoses. Third, a proportion of variables, including adequacy, receptor status, cost, and early-action fields, were incompletely recorded. Fourth, the number of lesions with paired FNAC results was too small for a balanced comparator analysis. Finally, free-text diagnostic entries required harmonization, which may introduce a small degree of misclassification despite conservative analytic rules.

Clinical Implications

TIC may be considered as a routine adjunct during breast core biopsy where rapid preliminary interpretation would alter patient flow, specimen triage, or counseling. In BI-RADS 4C and 5 lesions, a malignant TIC result can strengthen immediate radiologic-pathologic concordance and support expedited multidisciplinary planning. A benign TIC result in a highly suspicious lesion should not be accepted at face value; it should prompt close radiologic-pathologic review and consideration of repeat biopsy or excision. For laboratories in Libya and comparable settings, TIC offers a feasible alternative to more infrastructure-intensive rapid diagnostic approaches.

Conclusion

In this retrospective Libyan single-center series, touch imprint cytology of core needle biopsy specimens showed high specificity and excellent positive predictive value for the rapid diagnosis of breast malignancy when interpreted alongside imaging. Although sensitivity was more modest than in some benchmark series, the technique remained clinically useful as a rapid adjunct, particularly for specimen adequacy assessment and early recognition of malignant

lesions. Prospective implementation with standardized reporting, explicit adequacy criteria, and formal radiologic-pathologic concordance review would strengthen its role in breast cancer pathways across low-resource settings.

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