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Original Article

Comparative diagnostic efficiency of ultrasonography-guided core needle biopsy versus stereotactic-guided vacuum-assisted biopsy in breast microcalcifications: Results from a single academic institution

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Abstract

Background: Image-guided biopsy is essential for evaluating suspicious breast microcalcifications detected on mammography. At our institution, both ultrasonography-guided core needle biopsy (US-CNB) and stereotactic-guided vacuum-assisted biopsy (S-VAB) are routinely used based on imaging visibility and lesion characteristics.

Objective: To assess the diagnostic performance and workflow outcomes of US-CNB and S-VAB as utilized in routine clinical practice for evaluating mammographically detected microcalcifications without an associated mass.

Materials and Methods: We retrospectively reviewed 200 patients who underwent US-CNB (n=100) or S-VAB (n=100) between January 2019 and December 2023 at our institution. Clinical, imaging, and histopathological data were collected. Outcomes included the malignancy rate, DCIS underestimation rate, false-negative rate, microcalcification retrieval rate, and malignancy rate by BI-RADS category.

Results: Both biopsy methods demonstrated good diagnostic performance. US-CNB showed a higher malignancy rate (77%) than S-VAB (34%) ($p < 0.001$), attributed to imaging-driven selection of higher-risk lesions. DCIS underestimation was 42% for US-CNB and 24% for S-VAB ($p = 0.297$). One false-negative occurred in the US-CNB group. Microcalcification retrieval was confirmed in 81% of evaluated US-CNB cases and 100% of S-VAB cases ($p < 0.001$).

Conclusion: In our institutional workflow, both US-CNB and S-VAB are effective and complementary techniques. While malignancy rates differ due to imaging selection bias, diagnostic outcomes support the continued use of both methods as appropriate to lesion characteristics.

Keywords: Breast cancer, Breast microcalcifications, Core needle biopsy, DCIS underestimation, Ultrasonography-guided biopsy, Vacuum-assisted biopsy.

Introduction

Mammographically detected breast microcalcifications present a diagnostic challenge due to their potential to represent either benign conditions or early malignancies, such as ductal carcinoma in situ (DCIS) or invasive breast cancer [1]. Image-guided biopsy techniques have become indispensable for accurately characterizing these lesions and informing clinical management [2]. Among these, ultrasonography-guided core needle biopsy (US-CNB) and stereotactic-guided vacuum-assisted biopsy (S-VAB) are two prominent methods, each tailored to distinct imaging scenarios. US-CNB is typically employed when microcalcifications are visible on ultrasound, often in association with a mass, offering benefits like real-time guidance and reduced patient discomfort[3]. Conversely, S-VAB is favored for microcalcifications detectable only on mammography, leveraging stereotactic precision and vacuum assistance to retrieve larger tissue samples [4].

The diagnostic performance of these techniques has been examined in various studies. Research on US-CNB has demonstrated its effectiveness in diagnosing sonographically visible microcalcifications, with malignancy rates as high as 83.3% in some cohorts, though it may carry a higher risk of underestimating invasive components [1, 5]. S-VAB, by contrast, boosts calcification retrieval rates exceeding 95% and lowers false-negative rates, making it a reliable choice for mammogram-only lesions [6, 7].

This study seeks to address the diagnostic outcomes of US-CNB and S-VAB in patients with suspicious breast microcalcifications at our institution. We aim to compare malignancy rates, false-negative rates, and underestimation rates between these techniques. Our research intends to provide evidence-based insights for radiologists and clinicians. Such data could optimize the diagnostic approach to microcalcifications, ultimately improving patient care and outcomes in breast cancer detection.

Materials and methods

Study population

This single-center retrospective observational study was approved by the institutional review board of Siriraj Hospital (certificate of approval number Si 059/2025).

A retrospective review included female patients aged > 18 years who had microcalcifications detected on mammography and subsequently underwent either US-CNB or S-VAB at the Siriraj Breast Imaging Center between January 1, 2019, and December 31, 2023. Exclusion Criteria included a mass detected in association with the microcalcifications on the mammogram or incomplete data (e.g., no pathology reports available or no imaging follow-up for at least 1 year in cases with benign biopsy results).

The sample size was calculated to study the DCIS underestimation rate between US-CNB and S-VAB. Based on a previous study by Bae et al[1], the underestimation rate for US-CNB was 42% (5/12) and for S-VAB was 8.6% (3/35). For this study, we estimated an underestimation rate of 25% in the US-CNB group compared to 10% in the S-VAB group. Setting a two-sided $\alpha = 0.05$ and aiming for 80% power, the required sample size was calculated to be n=100 for the US-CNB group and n=100 for the S-VAB group. Patients were assigned to the US-CNB or S-VAB group based primarily on the sonographic visibility of the target microcalcifications or associated findings, reflecting standard clinical practice.

Imaging technique
Mammography was performed with the Fujifilm Amulet full-field digital mammography system (Fujifilm, Tokyo, Japan). The standard craniocaudal and mediolateral oblique views were routinely obtained along with additional magnification views upon request. If the correlation of calcifications on mammogram and ultrasound was uncertain, a radio-opaque marker was placed on the skin at the location of the lesion to confirm its position on mammography.

Ultrasound was performed in every case using one of the high-resolution US units with a linear probe of at least 12 MHz (Logiq E9, E10 (GE Medical Systems, Milwaukee, WI, USA), Aplio i700 (Canon Medical Systems, Otawara, Japan), Aplio 500 (Toshiba Medical Systems, Tokyo, Japan)).

Biopsy procedure and management
S-VAB and US-CNB were performed using distinct techniques tailored to the imaging visibility of microcalcifications. The procedure was conducted by a breast imaging specialist or a fellowship trainee under supervision of one of four breast imaging specialists with 5-30 years of experience.

US-CNB used a 14-gauge automated needle (Magnum reusable core biopsy gun, Bard, USA), guided by real-time ultrasound to target sonographically visible calcifications or associated masses. The number of cores obtained was recorded. Specimen radiography in the US-CNB group was performed selectively based on the radiologist's preference and technical confidence in lesion targeting. For S-VAB was performed using digital breast tomosynthesis (DBT)-guided biopsy of suspicious calcification, with patients positioned in a lateral decubitus or upright position for stereotactic guidance by Fujifilm Amulet full-field digital mammography add-on biopsy system (Fujifilm, Tokyo, Japan). No device allowing a lateral arm approach was available. A 9-gauge standard vacuum-assisted breast biopsy device (Atec, Hologic, Massachusetts, USA) was utilized to obtain tissue samples in every case. The procedure typically included a scout image, prefire image, postfire image and after clip placement (if any). Specimen radiograph was conducted routinely to confirm calcification retrieval in the S-VAB group. For ultrasound-guided core needle biopsy, a 14-gauge automated needle was used, and typically 4–5 cores were obtained per lesion according to institutional practice. For stereotactic-guided vacuum-assisted biopsy, a 9-gauge vacuum-assisted device was used, and generally 6–8 cores were retrieved per lesion based on institutional protocol. Patients with histopathological results of malignancy, atypical ductal hyperplasia, or discordant benign lesions proceeded to surgery. The final surgical pathology was considered the reference standard. Patients who did not undergo surgery were scheduled

for follow-up at 6 and 12 months. If the lesion progressed, surgery or re-biopsy was performed. However, the decision for surgery was determined by the surgeons.

Data analysis

Data were gathered from medical records, radiology reports and pathology reports to comprehensively characterize the US-CNB and S-VAB groups.

The primary outcome included the malignancy rate, the DCIS underestimation rate and the false negative rate.

The malignancy rate was calculated as the proportion of cases diagnosed as DCIS or invasive cancer. The DCIS underestimation rate was determined by the proportion of initial DCIS cases upgraded to invasive ductal carcinoma (IDC) at surgery, and the false negative rate was determined by the proportion of cases initially diagnosed as benign by the respective image-guided biopsy method (US-CNB or S-VAB) that were subsequently found to have malignancy upon definitive surgical excision or during the minimum one-year imaging follow-up period for those not undergoing surgery.

The secondary outcome was microcalcification retrieval rate and the malignancy rate according to BI-RADS category. The microcalcification retrieval rate was defined as the presence of microcalcifications on specimen radiographs.

The variables collected encompassed demographic details such as age, clinical symptoms (e.g., palpable mass, nipple discharge), and history of prior biopsies, alongside mammographic features including BI-RADS categories, breast composition, and calcification shape and distribution. For the US-CNB group, ultrasound-specific lesion characteristics, such as size, mass shape, margins, and echogenicity, were recorded. Biopsy-related data included the number of core specimens, presence of microcalcifications on specimen radiograph, initial CNB histological results (benign, DCIS, or invasive cancer), final histology post-surgery (within one year of follow-up), and the rate of upgrades from DCIS to invasive cancer.

Comparative analyses utilized chi-square tests for categorical data and t tests for continuous variables.

Statistical analyses were performed using SPSS 20.0 software (SPSS Inc., Chicago, IL, USA). P-values < 0.05 were considered statistically significant.

Results

Patient demographics and mammographic features

A total of 200 patients with suspicious breast microcalcifications were analyzed, with 100 undergoing ultrasonography-guided core needle biopsy (US-CNB) and 100 undergoing stereotactic-guided vacuum-assisted biopsy (S-VAB).

Patients' demographic data and mammographic features were summarized in table 1. Breast composition did not differ in both groups and was predominantly heterogeneously dense (75% and 71%, p = 0.42). The mean age was 52.6 years in the US-CNB group, significantly lower than 56.4 years in the S-VAB group (p = 0.005). Clinical symptoms were present in 39% of US-CNB patients, predominantly palpable masses (87%), compared to 3% in the S-VAB group (p < 0.001). BI-RADS categories showed significant differences, with the US-CNB group having a higher proportion of category 5 lesions (47%) and fewer 4A lesions (16%), while S-VAB group had more 4A (41%) and 4B (47%) lesions (p < 0.001). Calcification shape varied significantly, with fine pleomorphic shapes predominant in the US-CNB group (42%) and amorphous shapes in S-VAB (51%) (p < 0.001). Distribution patterns of calcifications also differed significantly, with segmental calcifications more common in US-CNB (20%) and grouped calcifications in S-VAB (71%) (p < 0.001).

Table 1. *Patient's demographic data and mammographic features according to biopsy methods.*

Parameter	US-CNB (n=100)	S-VAB (n=100)	p-value
Age (mean ± SD)	52.6 ± 9.3	56.4 ± 9.5	0.005
Clinical symptoms	39 (39)	3 (3)	<0.001
• Palpable mass	34/39 (87)	1/3 (33)	
• Nipple discharge	3/39 (8)	1/3 (33)	
• Nipple retraction	1/39 (3)	0 (0)	
• Pain	0 (0)	1/3 (33)	
• Skin retraction	1/39 (3)	0 (0)	
History of prior biopsies	3 (3)	11 (11)	0.027

Parameter	US-CNB (n=100)	S-VAB (n=100)	p-value
BI-RADS			<0.001
• 4A	16 (16)	41 (41)	
• 4B	23 (23)	47 (47)	
• 4C	14 (14)	11 (11)	
• 5	47 (47)	1 (1)	
Breast composition			0.42
• Almost entirely fatty	0 (0)	0 (0%)	
• Scattered fibroglandular	2 (2)	6 (6%)	
• Heterogeneously dense	75 (75)	71 (71)	
• Extremely dense	23 (23)	23 (23)	
Shape of calcifications			<0.001
• Amorphous	17 (17)	51 (51)	
• Coarse Heterogeneous	15 (15)	18 (18)	
• Fine Linear/Fine linear branching	8 (8)	9 (9)	
• Fine Pleomorphic	42 (42)	14 (14)	
• Round	18 (18)	8 (8)	
Distribution of calcifications			<0.001
• None	9 (9)	0 (0)	
• Diffuse	6 (6)	1 (1)	
• Grouped	47 (47)	71 (71)	
• Linear	2 (2)	5 (5)	
• Regional	16 (16)	17 (17)	
• Segmental	20 (20)	6 (6)	

Note: Data are numbers with percentages in parentheses unless indicated otherwise.

Ultrasound features of US-CNB lesions were described in Table 2.

Table 2. *Ultrasound features of US-CNB lesions.*

Characteristics	n = 100
Location of calcification	
• Inside a mass	81/100 (81)
• Intraductal calcification	11/100 (11)
• Outside a mass or duct	8/100 (8)
Lesion size (mm, median (range))	16.5 (3.9, 66)
Shape of associated mass	
• Irregular	55/81 (68)
• Oval	25/81 (31)
• Round	1/81 (1)
Orientation of associated mass	
• Not parallel	4/81 (5)
• Parallel	77/81 (95)
Margins of associated mass	
• Circumscribed	8/81 (10)
• Angular	4/81 (5)
• Indistinct	42/81 (52)
• Microlobulated	6/81 (7)
• Spiculated	21/81 (26)
Echogenicity of lesions	
• Complex Cystic and solid	1/81 (1)
• Heterogeneous	6/81 (8)
• Hypoechoic	74/81 (91)

Characteristics	n = 100
Posterior Feature	
• No posterior feature	67/81 (81)
• Enhancement	1/81 (1)
• Shadowing	9/81 (11)
• Combined pattern	6/81 (7)
Associated features	
• Ductal changes	16/31 (52)
• Architectural distortion	12/31 (39)
• Skin thickening	2/31 (6)
• Edema	1/31 (3)

Note: Data are numbers with percentages in parentheses unless indicated otherwise.

Primary outcome: Malignancy rate, DCIS underestimation rate and false negative rate

Malignancy rates were 77% for US-CNB and 34% for S-VAB ($p < 0.001$). Among lesions with malignancy pathology, invasive carcinoma was more frequent in the US-CNB group (53%) than in S-VAB (9%) with significant difference. (Table 3)

Table 3. *Biopsy details and histopathology according to biopsy methods.*

Parameter	US-CNB (n=100)	S-VAB (n=100)	p-value
Number of core specimens (Median(range))	5 (3, 9)	10 (6, 22)	< 0.001
Microcalcifications on specimen radiograph			< 0.001
Yes	35/43 (81)	100/100 (100)	
No	8/43 (19)	0 (0)	
Initial biopsy result			< 0.001
Benign	23 (23)	66 (66)	
Invasive cancer	53 (53)	9 (9)	
DCIS	24 (24)	25 (25)	
Surgery	81/100 (81)	46/100 (46)	< 0.001
Benign	3/81 (4)	12/46 (27)	
Malignant	78/81 (96)	34/46 (73)	
Upgrade from DCIS to IDC at surgery	10/24 (42)	6/25 (24)	0.187

The underestimation of DCIS which means an upgrade from DCIS to IDC at surgery, was 42% (10/24) for US-CNB and 24% (6/25) for S-VAB, with no significant difference (p = 0.187) (Figures 1 and 2)

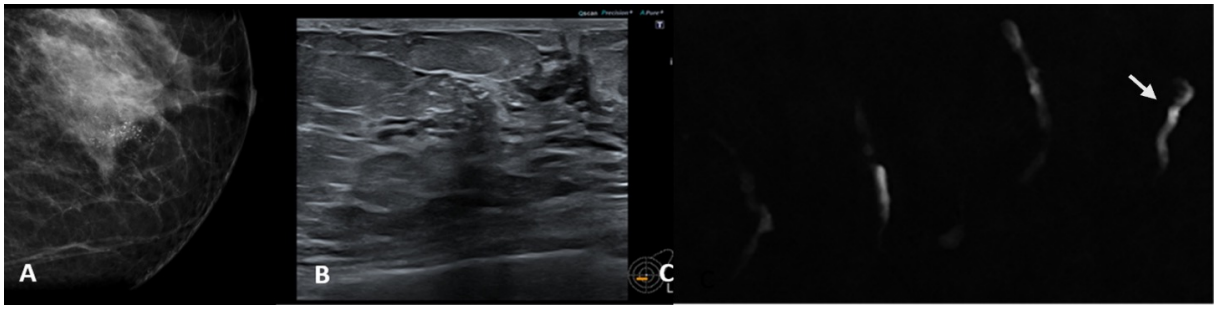

Figure 1. *A case with pathology upgraded from DCIS on CNB to IDC at surgery from the US-CNB group.*
(A) Mammogram shows fine pleomorphic and coarse heterogeneous microcalcifications in a segmental distribution at the left central to lower inner quadrant (LIQ), measuring 43.8 × 21.6 mm (BI-RADS 4B). (B) Corresponding ultrasound reveals a prominent duct with intraductal calcifications in the same region. (C) Specimen radiograph of US-CNB confirms microcalcifications in one of the five obtained cores. The initial pathology showed DCIS, intermediate nuclear grade, solid and cribriform patterns with comedonecrosis. Subsequent mastectomy revealed moderately differentiated IDC (histologic grade 2) along with residual DCIS.

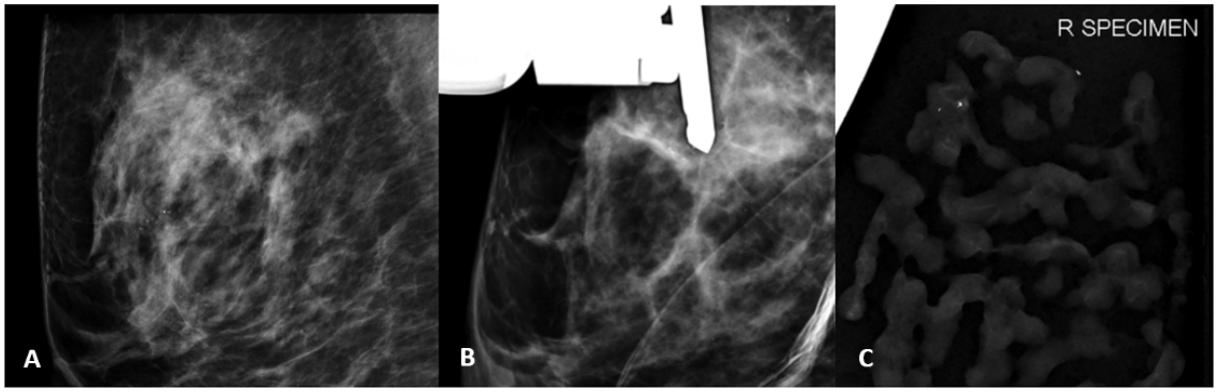

Figure 2. *A case with pathology upgraded from DCIS on CNB to IDC at surgery from the S-VAB group.*
(A) Mammogram reveals coarse heterogeneous microcalcifications in a linear distribution at the right upper breast (BI-RADS 4B). (B) S-VAB was performed under stereotactic guidance with 16 cores obtained. (C) Specimen radiograph confirms microcalcifications in four of the retrieved cores. The initial pathology demonstrated DCIS. Subsequent excisional biopsy revealed invasive ductal carcinoma.

One false negative case was identified in US-CNB group, and none were found in the S-VAB group. The false negative case presented with grouped fine pleomorphic calcifications on mammography and ultrasound-visible oval, indistinct hypoechoic mass. The ultrasound-guided CNB yielded five core specimens containing microcalcifications in one core. The initial biopsy result was benign breast tissue with dense collagenous and fibrotic stroma, with a focal pseudoangiomatous stromal hyperplasia-like appearance. Therefore, discordant radio-pathologic correlation was suspected, requiring surgical excision. The surgical pathology yielded atypical ductal hyperplasia with a focus of DCIS (Figure 3).

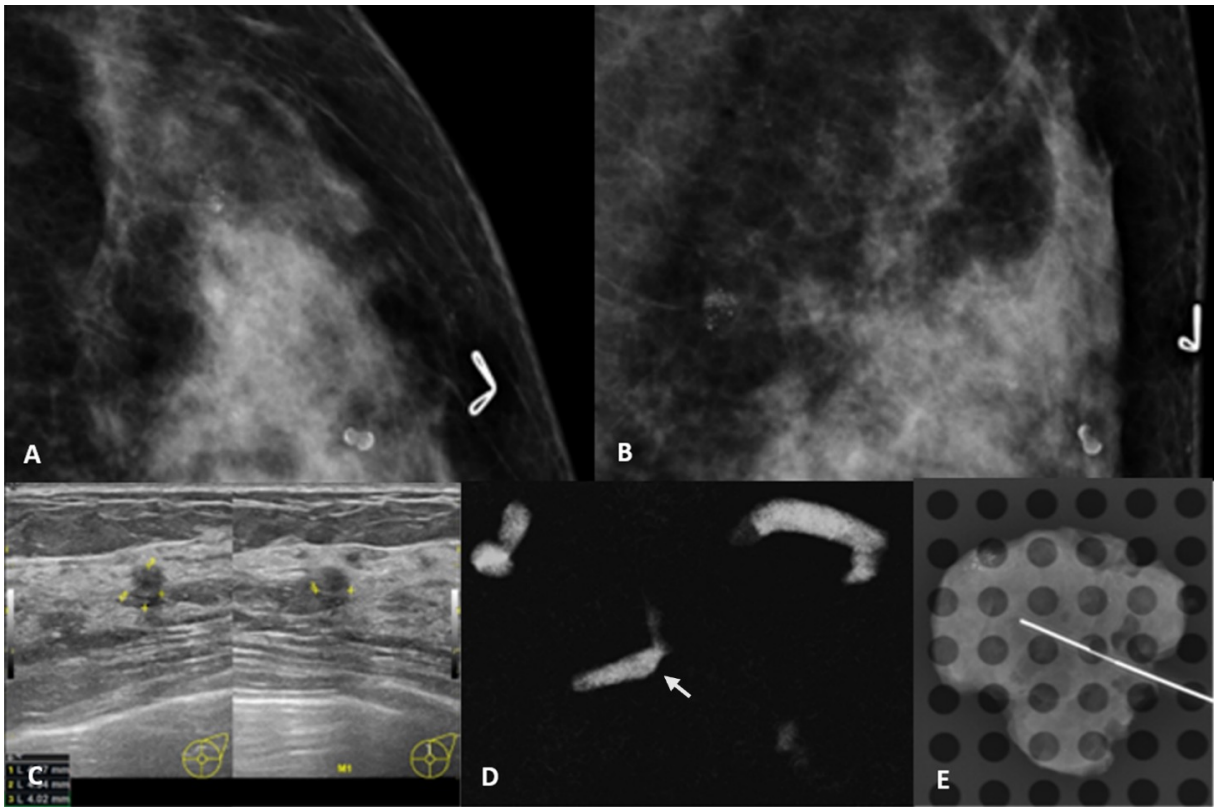

Figure 3. *A false negative case in US-CNB group.*
(A, B) Craniocaudal and mediolateral oblique mammograms show grouped fine pleomorphic microcalcifications at the upper outer quadrant (UOQ) of the left breast (BI-RADS 4B). (C) Ultrasound images reveal an oval, indistinct, hypoechoic mass measuring 4.9 mm without posterior acoustic features. (D) Specimen radiograph demonstrates microcalcifications within one of the four biopsy cores. (E) Biopsy setup showing targeting of the lesion under ultrasound guidance. Initial US-CNB pathology was benign fibrous tissue with dense collagenous and fibrotic stroma, with focal pseudoangiomatous stromal hyperplasia-like features. Due to discordant imaging-pathologic findings, surgical excision was performed and revealed atypical ductal hyperplasia with a focus of DCIS.

Secondary outcome: Microcalcification retrieval rate and malignancy rate according to BI-RADS category

Specimen radiography was performed in 43/100 cases in the US-CNB group, and all (100/100) in the S-VAB group. Microcalcification retrieval rate on specimen radiograph significantly differed between groups with US-CNB retrieving calcifications in 81% (35/43), failing in 8 cases (8/43) but successful S-VAB retrieving calcifications in 100% ($p < 0.001$) (Table 3).

The malignancy rate according to BI-RADS category was reported in Table 4. Most malignancy rates by BI-RADS category conformed to the published data in the BI-RADS manual. However, in the BI-RADS 4A category, the malignancy rate was 38% in US-CNB group and 20% in S-VAB group, which exceeded the expected range indicated in the BI-RADS manual.

Table 4. *Malignancy rates by BI-RADS category.*

BI-RADS Category	Malignancy Rate	
	US-CNB (n=100)	S-VAB (n=100)
4A	6/16 (38)	8/41 (20)
4B	13/23 (57)	17/47 (36)
4C	12/14 (86)	9/11 (73)
5	46/47 (98)	1/1 (100)

Note: Data are numbers with percentages in parentheses.

Discussion

Our results demonstrated the diagnostic outcomes of US-CNB and S-VAB for suspicious breast microcalcifications at a single tertiary-care institution. The results show that the malignancy rate was significantly higher in the US-CNB group (77%) compared to the S-VAB group (34%) ($p < 0.001$). There was one false negative case (1/100) in US-CNB group while there is none in the S-VAB group and there was no significant difference of the DCIS underestimation rate between the two groups (42% for US-CNB versus 24% for S-VAB; $p = 0.187$).

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The significant higher malignancy rate in the US-CNB group compared to the S-VAB group could be explained and was biased by differences in clinical indications for each procedure. The US-CNB group included a higher proportion of lesions with strong predictors of malignancy, such as BI-RADS 5 assessments (47% vs 1%), fine pleomorphic calcifications (42% vs 14%), segmental distribution (20% vs 6%), the presence of clinical symptoms (39% vs 3%), and associated ultrasound-visible masses (81%). These features are well known to correlate with a higher risk of malignancy[1, 8]. In contrast, the S-VAB group mainly consisted of lower-risk lesions, including a higher proportion of BI-RADS 4A and 4B assessments (88%) and amorphous calcifications (51%). Therefore, the higher malignancy rate observed in the US-CNB group reflects the higher-risk nature of the lesions selected for biopsy, rather than a true difference in the diagnostic performance between US-CNB and S-VAB.

In this study, one false-negative case was identified in the US-CNB group, while none were identified in the S-VAB group. This underscores the importance of radiologic-pathologic correlation[1, 9]. In concordance with Youk et al., who reported a false-negative rate of 2.5% for US-CNB in breast masses with DCIS being the most frequently missed diagnosis [9]. In our case, the biopsy result with US-CNB initially revealed benign. However, due to imaging-pathology discordance, surgical excision was pursued and the final pathology subsequently revealed DCIS. This false-negative outcome is possibly explained by insufficient sampling, as the tissue obtained may not have adequately represented the full extent of the lesion. Only one of the five cores contained microcalcifications. Bagnall (2000) showed that increased sensitivity of the stereotactic biopsy for calcifications was related to the number of calcifications on specimen radiography, with three or more cores containing calcium achieving 100% sensitivity [10]. Emphasizing the importance of obtaining an adequate number of calcifications in the tissue cores to minimize the risk of underdiagnosis [5, 10, 11]. No false negatives were found in the S-VAB group, consistent with the high reliability reported for VAB [4, 7].

The rate of upgrade from DCIS to IDC at surgery was numerically higher for US-CNB (42%, 10/24) than for S-VAB (24%, 6/25), but this difference was not statistically significant ($p = 0.187$). Similar to our results, previous literature has reported lower underestimation rates for VAB compared to CNB, attributed to the larger tissue volume obtained[1, 2]. The upgrade rate with both US-CNB (using a 14-gauge needle) and S-VAB (using a 9-gauge device) in our study were also consistent with the rate reported in the previous studies[1, 6, 9, 12, 13]. The higher upgrade rate observed in the US-CNB may be due to the significantly lower number of cores obtained (median 5 for US-CNB vs 10 for S-VAB) [1, 5].

The reported microcalcification retrieval rate for S-VAB in our study was 100% (100/100 assessed cases), aligning with literature benchmarks where retrieval rates confirmed by specimen radiography typically exceed 95% for vacuum-assisted systems [1, 4, 6]. For US-CNB, calcifications were reported as retrieved in 81% (35/43) of the cases where specimen radiography was performed. Although specimen radiography was not conducted in 57% (57/100) of the US-CNB procedures, the observed retrieval rate still falls within the previously reported range of 71%–97% in studies utilizing specimen radiography for US-CNB [3, 5, 10, 14, 15].

The malignancy rate according to BI-RADS category in this study mostly follows the BI-RADS manual, except for the BI-RADS 4A category. The malignancy rate in BI-RADS 4A category exceeded the BI-RADS manual which is 38% in US-CNB group and 20% in S-VAB group. The result may be attributed to practice at our institution in which BI-RADS categories may have been under-assigned due to cognitive factors, such as conservative bias, potentially varying by radiologist experience. Based on our observations, those US-CNB BI-RADS 4A cases mostly reported with grouped coarse heterogeneous calcifications and/ or associated with an oval indistinct mass on ultrasound. In S-VAB BI-RADS 4A cases, most cases were grouped amorphous calcifications. According to the BI-RADS 2013's manual, this can be categorized as BI-RADS 4B then explaining the malignancy rate at over 10% [16].

There are several limitations in our study. First, the retrospective design introduced potential biases—the selection bias driven by differing indications based on sonographic visibility, resulting in different baseline cohorts. Second, this study may have been underpowered to detect true differences in the DCIS upgrade rate so that generalizability of this result may be limited by a single-center study. Third, specimen radiography was not done in all US-CNB cases. This may invalidate the comparison of calcification retrieval rates between two groups. Our study included cases from real practices at our institution which were circulated by breast specialist radiologists with varying experiences. An audit of a breast imaging practice and assessment of reader accuracy may provide valuable feedback for readers and facility improvement.

Conclusion

In our institutional workflow, both US-CNB and S-VAB are effective and complementary techniques. While malignancy rates differ due to imaging selection bias, diagnostic outcomes support the continued use of both methods as appropriate to lesion characteristics.

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Ethic

This retrospective study was approved by the Siriraj Institutional Review Board (SiRB), Faculty of Medicine Siriraj Hospital, Mahidol University. The requirement for informed consent was waived due to the retrospective nature of the study and anonymization of patient data.

References

1. Bae S, Yoon JH, Moon HJ, Kim MJ, Kim E-K. Breast microcalcifications: diagnostic outcomes according to image-guided biopsy method. Korean J Radiol. 2015;16(5): 996.

2. Huang XC, Hu XH, Wang XR, Zhou CX, Wang FF, Yang S, et al. A comparison of diagnostic performance of vacuum-assisted biopsy and core needle biopsy for breast microcalcification: a systematic review and meta-analysis. Ir J Med Sci. 2018; 187:999-1008.

3. Soo MS, Baker JA, Rosen EL. Sonographic detection and sonographically guided biopsy of breast microcalcifications. AJR Am J Roentgenol. 2003;180(4):941-8.

4. Kettritz U, Rotter K, Schreer I, Murauer M, Schulz-Wendtland R, Peter D, et al. Stereotactic vacuum-assisted breast biopsy in 2874 patients: a multicenter study. Cancer. 2004;100(2):245-51.

5. Yi J, Lee EH, Kwak JJ, Cha JG, Jung SH. Retrieval rate and accuracy of ultrasound-guided 14-G semi-automated core needle biopsy of breast microcalcifications. Korean J Radiol. 2014;15(1):12-9.

6. Liberman L, Smolkin JH, Dershaw DD, Morris EA, Abramson AF, Rosen PP. Calcification retrieval at stereotactic, 11-gauge, directional, vacuum-assisted breast biopsy. Radiology. 1998;208(1):251-60.

7. Jackman RJ, Marzoni Jr FA, Rosenberg J. False-negative diagnoses at stereotactic vacuum-assisted needle breast biopsy: long-term follow-up of 1,280 lesions and review of the literature. AJR Am J Roentgenol. 2009;192(2):341-51.

8. Popat PBT, Karbhari A, Shetty N, Gala K, Haria P, Katdare A, et al. Safety and Efficacy of Vacuum-Assisted Breast Biopsies under Ultrasound and Stereotactic Guidance. J Clin Interv Radiol ISVIR. 2023;7(03):172-8.

9. Youk JH, Kim E-K, Kim MJ, Kwak JY, Son EJ. Analysis of false-negative results after US-guided 14-gauge core needle breast biopsy. Eur Radiol. 2010;20:782-9.

10. Bagnall M, Evans A, Wilson A, Burrell H, Pinder S, Ellis I. When have mammographic calcifications been adequately sampled at needle core biopsy? Clin Radiol. 2000;55(7):548-53.

11. Margolin FR, Kaufman L, Jacobs RP, Denny SR, Schrumpf JD. Stereotactic core breast biopsy of malignant calcifications: diagnostic yield of cores with and cores without calcifications on specimen radiographs. Radiology. 2004;233(1):251-4.

12. Shrestha A, Wilkinson L, Given-Wilson R, Curtis J. Quantitative study: should vacuum-assisted biopsy be the first biopsy approach in breast interventional techniques in stereotactic guided microcalcifications rather than 14 gauge core needle biopsy? Breast Cancer Res. 2015;17(Suppl 1):P29.

13. Kim HS, Kim MJ, Kim E-K, Kwak JY, Son EJ, Oh KK. US-guided vacuum-assisted biopsy of microcalcifications in breast lesions and long-term follow-up results. Korean J Radiol. 2008;9(6):503-9.

14. Cho N, Moon WK, Cha JH, Kim SM, Jang M, Chang JM, et al. Ultrasound-guided vacuum-assisted biopsy of microcalcifications detected at screening mammography. Acta Radiol. 2009;50(6):602-9.

15. Hahn SY, Shin JH, Han B-K, Ko EY. Sonographically-guided vacuum-assisted biopsy with digital mammography-guided skin marking of suspicious breast microcalcifications: comparison of outcomes with stereotactic biopsy in Asian women. Acta Radiol. 2011;52(1):29-34.

16. D'Orsi CJ, Sickles EA, Mendelson EB, Morris EA. ACR BI-RADS® Atlas, Breast Imaging Reporting and Data System. Reston, VA: American College of Radiology; 2013.