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Comparison of the underestimation rate in cases with ductal carcinoma *in situ* at ultrasound-guided core biopsy: 14-gauge automated core-needle biopsy *vs* 8- or 11-gauge vacuum-assisted biopsy

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Objective: The objective of this study was to compare the underestimation rate of invasive carcinoma in cases with ductal carcinoma *in situ* (DCIS) at percutaneous ultrasound-guided core biopsies of breast lesions between 14-gauge automated core-needle biopsy (ACNB) and 8- or 11-gauge vacuum-assisted biopsy (VAB), and to determine the relationship between the lesion type (mass or microcalcification on radiological findings) and the DCIS underestimation rate.
Methods: We retrospectively reviewed imaging-guided biopsies of breast lesions performed from February 2003 to August 2008. 194 lesions were diagnosed as DCIS at ultrasound-guided core biopsy: 138 lesions in 132 patients by 14-gauge ACNB, and 56 lesions in 56 patients by 8- or 11-gauge VAB. The histological results of the core biopsy samples were correlated with surgical specimens. The clinical and radiological findings were also reviewed. The histological DCIS underestimation rates were compared between the two groups and were analysed for differences according to the clinical and radiological characteristics of the lesions.
Results: The DCIS underestimation rate was 47.8% (66/138) for 14-gauge ACNB and 16.1% (9/56) for VAB ($p<0.001$). According to the lesion type on sonography, DCIS underestimation was 43.4% (63/145) in masses (47.6% using ACNB and 15.8% using VAB; $p=0.012$) and 24.5% (12/49) in microcalcifications (50.0% using ACNB and 16.2% using VAB; $p=0.047$).
Conclusion: The underestimation rate of invasive carcinoma in cases with DCIS at ultrasound-guided core biopsies was significantly higher for ACNB than for VAB. Furthermore, this difference does not change according to the lesion type on ultrasound. Therefore, ultrasound-guided VAB can be a useful method for the diagnosis of DCIS lesions presented as either mass or microcalcification.

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Ductal carcinoma *in situ* (DCIS) is mostly presented as microcalcification on radiography. Therefore, previous reports regarding the accuracy of core biopsy in DCIS have mainly focused on stereotactic (ST) guidance [1–4]. With the development and introduction of high-resolution ultrasound, several reports have studied various applications of ultrasound on the core biopsy for breast lesions, including ultrasound-guided core biopsy for microcalcification [5–9] and ultrasound-guided vacuum-assisted removal [10]. Ultrasound guidance has several advantages over ST guidance: a lack of ionising radiation, use of non-dedicated equipment, real-time needle visualisation, multidirectional sampling, lower cost [8, 11] and less patient discomfort [8, 11–13]. For these reasons, ultrasound-guided core biopsy may be preferable in lesions that are amenable to core biopsy with both ST and ultrasound guidance.

One critical issue in percutaneous biopsy for diagnosis of DCIS may be DCIS underestimation, which means the underestimation of invasive cancer in cases where the core biopsy shows DCIS [1]. As underestimated DCIS at the core biopsy is upgraded to invasive carcinoma at surgery, axillary node dissection at a later date and thus a two-stage therapeutic surgical procedure can be resulted in [1]. The DCIS underestimation rate in ST-guided core biopsy is generally 10–36% with a large number of cases. Among them, 11-gauge vacuum-assisted biopsy (VAB) is well known to show a significantly lower DCIS underestimation rate than 14-gauge automated core-needle biopsy (ACNB) under ST-guidance [1, 14–16]. However, studies with ultrasound-guided core biopsy have not found significant differences in DCIS underestimation

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between ACNB and VAB [17–18]. Moreover, previous studies using ultrasound guidance included only a small number of cases, and it is not well established whether the biopsy device (ACNB or VAB) and lesion type (microcalcification or mass) would affect the underestimation rate under ultrasound guidance.

The purpose of this study was to compare the underestimation rate of invasive carcinoma in cases with DCIS at ultrasound-guided core biopsies between 14-gauge ACNB and VAB, and to determine the relationship between lesion types (mass or microcalcification on radiological findings) and the DCIS underestimation rate.

Methods and materials

This retrospective study was conducted with institutional review board approval and patient informed consent was waived.

Study population

From a retrospective review of the radiological database of our institution from February 2003 to August 2008, we found 207 breast lesions that were diagnosed as DCIS from 6012 imaging-guided biopsies, comprising 5061 ultrasound-guided ACNB, 921 ultrasound-guided VAB and 30 ST-guided VAB (Figure 1). Among 207 DCIS lesions, 3 lesions with ST-guided VAB were excluded. No lesion was diagnosed as DCIS with MR-guided biopsy during the study period. Therefore, a total of 204 consecutive lesions were diagnosed as DCIS at ultrasound-guided core biopsies (138 lesions in 132 patients using 14-gauge ACNB and 66 lesions in 66 patients using 8- or 11-gauge VAB). Excluding 10 patients who were lost during the follow-up, 188 patients with 194 DCIS lesions (138 lesions in 132 patients using ACNB and 56 lesions in 56 patients using VAB) who underwent surgical excision at our institution made up our study population (mastectomy in 145 patients and conserving surgery in 43 patients). Of the 132 patients in the ACNB group, 126 patients had one lesion biopsied while 6 patients had biopsies of two separate lesions. All 56 patients in the VAB group underwent biopsy for one lesion.

Biopsy procedures

The breast biopsy device that was used depended primarily on the standard protocol of our institution (Figure 2). At our institution, ultrasound was subsequently performed for a mammographically detected lesion, which was indicated for biopsy, classified as Breast Imaging Reporting and Data System (BI-RADS) final assessment category 4 or 5. When the lesion on mammography was not visible in ultrasound or not correlated with ultrasound finding, ST-guided VAB was performed. If any mass or microcalcification (hyperechoic foci that was not related to Cooper's ligament) was detected on ultrasound at the location that may be correlated with the location of mammography, mammography was performed with the skin marker attached to the site at which the mass or microcalcification was seen on ultrasound. If the ultrasound-detected mass or microcalcification was correlated with the mammography-detected lesion, ultrasound-guided core biopsy was subsequently performed for this lesion. Selection of biopsy device among ACNB or VAB under ultrasound guidance was dependent on the lesion factors and clinical factors as follows. Generally, ultrasound-guided 14-gauge ACNB is initially performed to biopsy sonographically visible breast masses regardless of the palpability of the lesion [12, 19–20]. However, VAB was preferred for lesions in which there were potential benefits from using the device [8, 21], including lesions with heterogeneous characteristics, intraductal lesions and microcalcification visible in ultrasound. For microcalcification, even if presented without an associated mass, ultrasound-guided VAB was preferred over ST-guided whenever the lesion was sonographically visible and correlated with mammographic abnormality, considering the aforementioned advantages of ultrasound-guided over ST-guided. Although ACNB was mainly performed for mass lesions, if the patient or referring physician preferred removal of the lesion with concurrent histological diagnosis, mass lesions were also indications for VAB. However, a mass lesion classified as BI-RADS final assessment category 4c or 5 was not an indication of VAB for an aim of removal of the lesion. Although this protocol was present, the physician's and patient's preferences also affected the decision.

All biopsies were performed using the freehand technique, guided by high-resolution sonography units with a 12-MHz linear array transducer (ATL HDI 5000; Philips Advanced Technology Laboratories, Bothell, WA) with the patient in the supine or oblique supine position. Of the 194 DCIS lesions, ultrasound-guided ACNB was performed in 138 breast lesions using automated guns (Pro-Mag 2.2; Manan Medical Products,

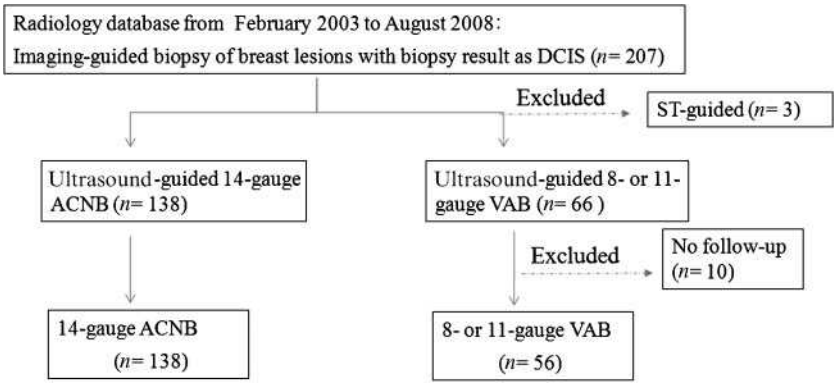

Figure 1. Flow chart of the study. DCIS, ductal carcinoma *in situ*; ST, stereotactic.

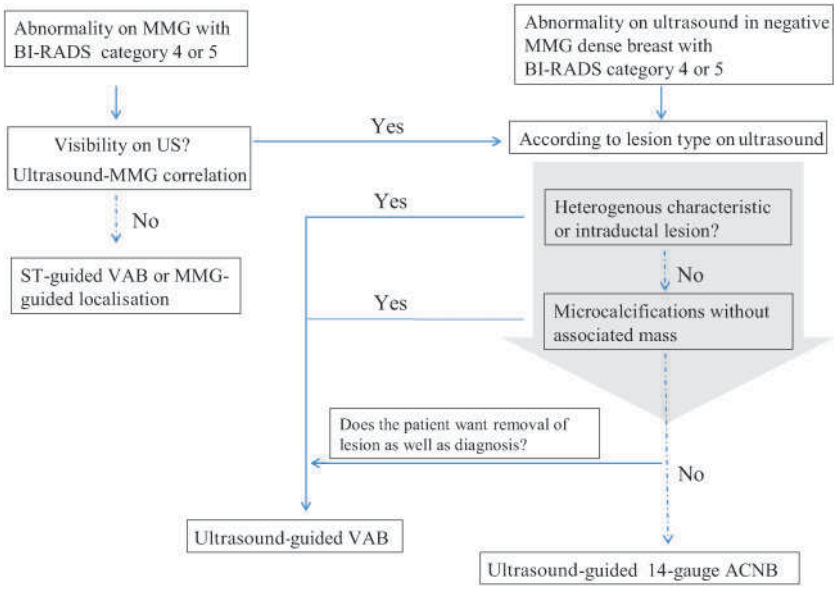

Figure 2. Biopsy protocol of breast lesion for selection of the devices at our institution. ACNB, automated core-needle biopsy; BI-RADS, Breast Imaging Reporting and Data System; ST, stereotactic.

Northbrook, IL) and 14-gauge Tru-cut needles with a 22-mm throw. VAB was performed in 56 lesions using 8- or 11-gauge needles (Mammotome; Ethicon-Endosurgery, Cincinnati, OH). When VAB was used, an 8-gauge needle was selected for a lesion larger than 1.5 cm diameter and 11-gauge was for a lesion of 1.5 cm or smaller diameter, but each radiologist's preference was also considered. Following our standard protocol, four to six core samples per lesion were obtained using ACNB by one of our four board-certificated radiologists. When VAB was used, the procedure was usually performed at the discretion of each radiologist, depending on the size of the lesion as seen on sonography and on the aim of VAB. Whenever a lesion that contained microcalcifications was biopsied, a specimen radiograph was obtained to document the presence of calcifications. The maximum diameter of the lesion was measured by sonography before the biopsy procedure and used as the parameter indicating the size of the lesion throughout this study.

Prior to core biopsy, the lesions were prospectively characterised according to the guidelines of the American College of Radiology BI-RADS final assessment categories both on mammography and sonography by the radiologist who performed the biopsy [19]. The aim of the biopsy (either diagnostic or removal) in the case of a VAB lesion was recorded. Post-biopsy complication (*e.g.* bleeding, skin laceration) was also recorded.

Imaging and histological evaluation

For this study, all imaging studies were retrospectively reviewed by MJK (8 years of experience with breast imaging), who was blinded to the surgical pathological diagnosis. The images were reviewed on a picture archiving and communications system (Centricity 2.0; GE Healthcare, Waukesha, WI).

Based on the results of the retrospective review, the characteristics of the lesions on mammography and sonography were described in terms of the lesion type and size. Aside from 10 lesions in the ACNB group and 1 lesion in the VAB group, mammography was available for all lesions.

On mammography, the lesion type was classified into one of two groups according to the characteristics of the lesion: mass or microcalcification. Any mass, architectural distortion or asymmetry seen on mammography, with or without calcifications, was classified as a mass. If microcalcification was presented without an associated mass, architectural distortion or asymmetric density on mammography, it was classified as a microcalcification. On sonography, all lesions were also classified as either a mass or microcalcification. Any mass seen on sonography, regardless of the presence of microcalcifications, was classified as a mass. If microcalcification was present without an associated mass, the lesion was classified as a microcalcification.

The histological results of the core biopsy samples were correlated with the pathological report on surgical specimens. Histological DCIS underestimation of invasive carcinoma was defined as DCIS diagnosed via core biopsy that was later upgraded to invasive carcinoma at surgery. DCIS with microinvasion was considered as invasive carcinoma. The DCIS underestimation rate was defined as the percentage of the number of invasive carcinomas upgraded at subsequent surgery divided by the number of total lesions or patients diagnosed as DCIS at core biopsy.

Outcome analysis

Statistical comparisons were performed between the ACNB group and the VAB group in terms of the clinical and imaging characteristics: symptoms, patient's age, lesion size, final assessment of BI-RADS category and lesion type on imaging study. In cases of VAB, clinical and imaging characteristics of the lesion and the mean number of core samples were compared according to the diameter of the biopsy needle used (8-gauge *vs* 11-gauge).

The DCIS underestimation rates of the two biopsy methods were compared per lesion and per patient. In cases of VAB, the DCIS underestimation rate for 8- and 11-gauge needle was obtained. The rates were also analysed with respect to the type of the lesion on sonography or mammography and the final assessment of the BI-RADS category.

Student's *t*-test was performed to compare the patient ages, lesion sizes and the numbers of samples obtained per lesion between the two biopsy groups. The χ^2 test or Fisher's exact test was performed to compare sonographic and mammographic lesion types with DCIS underestimation rates. For all analyses, the results were considered statistically significant if the *p*-value was <0.05. For statistical analysis, we used a computerised statistics program (Med-Calc for Windows, v. 8.0.0.1; MedCalc Software, Mariakerke, Belgium).

Results

The data in Table 1 demonstrate the clinical and imaging variables of the lesions in the ACNB and VAB groups. There were associated symptoms present in 68 cases (34.7%): a palpable mass in 57 cases, bloody nipple discharge in 10 cases and both in 1 ACNB case. The lesion size measured by sonogram ranged from 4 to over 100 mm (mean 18.5 mm; median 15.0 mm). There was no significant difference in the mean lesion size between the two biopsy groups ($p=0.28$). The distribution of BI-RADS category was not different between the two groups ($p=0.06$). The percentage of microcalcification lesions on sonography and mammography compared with the percentage of mass lesions was significantly higher in the VAB group than in the ACNB group ($p<0.001$). The mean number of core samples obtained was 5.01 (range 3–17) for 14-gauge ACNB and 11.8 (range, 5–28) for 8- and 11-gauge VAB ($p<0.0001$).

An 8-gauge needle was used in 16 lesions and an 11-gauge needle was used in 40 lesions, according to the size of the lesion. The lesion size had a mean of 20.5 mm (range 15–33 mm, median 18.5 mm) in the 8-gauge group and a mean of 11.9 mm (range 5–17 mm, median 12.0 mm) in the 11-gauge group ($p=0.013$). The mean number of core samples was 12.9 (range 7–28) for 8-gauge VAB and 11.3 (range 5–23) for 11-gauge VAB ($p=0.24$). There was no statistically significant difference between the cases with 8-gauge and those with 11-gauge regarding the lesion type on mammography ($p=0.23$), that on sonography ($p=0.13$), the presence of symptoms ($p=0.20$) and the distribution of BI-RADS category ($p=0.24$). Among 56 VAB cases, nine lesions (four with 8-gauge and five with 11-gauge) were performed for removal of mass lesion.

Histological ductal carcinoma in situ *underestimation rate*

Of the 194 lesions in 188 patients that were given the pathological diagnosis of DCIS in core biopsy, the final pathological results of surgical resection showed an invasive component in 38.7% of the cases (75/194). DCIS underestimation occurred in 47.8% (66/138) of the ACNB cases and in 16.1% (9/56) of the VAB cases ($p<0.001$; Table 2). Among the six patients who had two separate lesions, five had the same diagnosis at surgery for the two lesions (DCIS for two patients and IDC for

Table 1. Patient and lesion variables in lesions diagnosed as DCIS by 14-gauge ACNB and 8- and 11-gauge VAB

Variable	ACNB ($n=138$)	VAB ($n=56$)	Total ($n=194$)	*p*-value
Patient age (years)				0.89
Mean ± SD	47.8 ± 10.2	48.0 ± 10.5	47.8	
Range	24–88	25–70	24–88	
Associated symptoms[a]	58	10	68[b]	
Lesion size (mm)[c]				0.001
Mean ± SD	18.9 ± 13.2	15.5 ± 7.81	18.5 ± 12.7	0.28
Range	4–100	5–33	4–100	
BI-RADS category				0.06
3	1 (0.7)	2 (3.5)		
4a	39 (28.3)	16 (28.6)		
4b	12 (8.7)	9 (16.1)		
4c	31 (22.5)	17 (30.4)		
5	55 (39.8)	12 (21.4)		
Lesion type on mammography	128[d]	55[d]		<0.001
No abnormality	20 (15.6)	6 (10.9)	26	
Mass	58 (45.3)	7 (12.7)	65	
Microcalcification	50 (39.1)	42 (76.4)	92	
Lesion type on sonography				<0.001
Mass	126 (91.3)	19 (33.9)	145	
Microcalcification	12 (8.7)	37 (66.1)	49	

ACNB, automated core-needle biopsy; BI-RADS, Breast Imaging Reporting and Data System; DCIS, ductal carcinoma *in situ*; SD, standard deviation; VAB, vacuum-assisted biopsy.
The numbers in parentheses are percentages.
[a]Associated symptoms indicate palpable breast mass or bloody discharge.
[b]One patient in ACNB had both symptoms; palpable mass and bloody discharge.
[c]Size of lesion was measured using sonography by radiologist who performed biopsy.
[d]Number of lesions by mammography was available.

Table 2. The DCIS underestimation rates for the two biopsy devices according to the type of lesion on sonography

Variable	ACNB	VAB	Total	*p*-value
Per lesion	66/138 (47.8)	9/56 (16.1)	75/194 (38.7)	<0.001
Lesion type on sonography				
Mass	60/126 (47.6)	3/19 (15.8)	63/145 (43.4)	0.012
Microcalcification	6/12 (50.0)	6/37 (16.2)	12/49 (24.5)	0.047
Lesion type on mammography				
No abnormality	12/20 (60.0)	2/6 (33.3)	14/26 (53.8)	0.37
Mass	26/58 (44.8)	1/7 (14.3)	27/65 (41.5)	0.22
Microcalcification	24/50 (48.0)	6/42 (14.3)	30/92 (32.6)	<0.001
Per patient	64/132 (48.5)	9/56 (16.1)	75/188 (39.9)	<0.001
Lesion type on sonography				
Mass	58/120 (48.3)	3/19 (15.8)	61/139 (43.9)	0.011
Microcalcification	6/12 (50.0)	6/37 (16.2)	12/49 (24.5)	0.047

ACNB, automated core-needle biopsy; VAB, vacuum-assisted biopsy.
The numbers in the parentheses are percentages.

three patients), while only one patient had a different diagnosis for each lesion (DCIS for one and IDC for another). We considered the last patient to be underestimated. Thus, DCIS underestimations per patient were 39.9% (75/188), representing 48.5% (64/132) for ACNB, and 16.1% (9/56) for VAB.

According to the diameter of the biopsy needle used in the VAB lesions, the DCIS underestimation rate was 18.8% (3/16) for lesions diagnosed with 8-gauge VAB and 15% (6/40) for lesions diagnosed with 11-gauge VAB. Because there was not a significant difference between the underestimation rates for the 8- and 11-gauge vacuum-assisted probes ($p=0.95$), data for the two probes were combined throughout the study.

According to the types of the lesions by sonography, the DCIS underestimation rate was 43.4% (63/145) for mass lesions and 24.5% (12/49) for microcalcification lesions ($p=0.029$). For masses, the DCIS underestimation rate was 47.6% (60/126) with ACNB and 15.8% (3/19) with VAB, and the difference between the two groups was statistically significant ($p=0.012$). For microcalcifications, the rate was 50.0% (6/12) with ACNB and 16.2% (6/37) with VAB, and this difference was also significant ($p=0.047$).

Concerning the types of the lesions as diagnosed by mammography, 53.8% (14/26) of lesions showed no abnormality in mammography, and 41.5% (27/65) of masses and 32.6% (30/92) of microcalcifications were underestimated as DCIS ($p=0.12$). In the differences of DCIS underestimation between the two biopsy device groups, there was statistical significance in the cases involving microcalcifications ($p<0.001$) on mammography.

No post-biopsy complication was noted in either biopsy device group.

Discussion

In previous reports, the diagnosis of DCIS using percutaneous imaging-guided core biopsies of breast lesions underestimated the presence of invasive breast cancer in 15–36% of the cases when using ACNB and in 10–31% of cases when using VAB under ST guidance (Table 3). Under ultrasound guidance, the DCIS underestimation rates were 39–67% for 14-gauge ACNB and 17–41% for VAB [3, 17, 20–23]. Our ultrasound-guided ACNB DCIS underestimation rate (47.8%) was compatible with the ultrasound-guided ACNB underestimation rates in previous reports, but was higher than the ST-guided rates. For VAB, the DCIS underestimation rate (16.1%) in our study was slightly lower than the rates with both ST and ultrasound guidance in previous reports. Finally, the differences of DCIS underestimation between the two biopsy methods ($p<0.001$) showed statistical significance in our study. There are several possible reasons for this observed difference. First, ultrasound guidance was used in our study. In previous studies, a higher DCIS underestimation was seen in ultrasound-guided ACNB than in ST-guided ACNB [1–2, 5, 17, 23–24]. This is consistent with the higher underestimation of DCIS lesions that presented as a mass lesion on radiography [1, 3, 17], considering that ultrasound-guided ACNB was applied to sonographically visible mass lesions in our study. Second, the amount of tissue samples obtained in VAB cases may have been larger than in previous studies. VAB cases in which a larger-diameter needle was used (8-gauge) were included in our study. Previous reports only included 11-gauge needles, and the larger needles in our report could allow for the acquisition of more tissue, which may result in a lower DCIS underestimation rate. Despite this theoretical advantage of larger needles, the underestimation rates of 8-gauge probes and 11-gauge probes were similar in our study ($p=0.95$), even though the mean diameter of the lesions was larger in the 8-gauge cases ($p=0.013$). Therefore, the possible effect of the 8-gauge probe on the DCIS underestimation should be addressed in a future study.

Recently, Cho et al [17] compared the outcomes of 14-gauge ACNB and 11-gauge VAB used in ultrasound-guided core biopsies of breast lesions, and found DCIS underestimation of 50% (5/10) for 14-gauge ACNB and 41% (7/17) for 11-gauge VAB, but the difference was not statistically significant. A lower DCIS underestimation rate of VAB in our study (16.5%) was possibly due to a larger number of cases, the cases of lesion removal and/or the cases in which the larger 8-gauge biopsy needle was used. Moreover, for the biopsies performed using 11-gauge VAB, the mean number of core samples reported in Cho et al's study was 10.2 (range 6–30) [17], while the mean number of core samples in our study was 11.3 (range 5–23). Considering the larger mean size of

Table 3. Reference review of DCIS underestimation rates: comparison of biopsy devices

Reference	Publication year	Guidance	Devices	No. of biopsied lesions	No. of included DCIS lesions at biopsy	Rate of DCIS in biopsied lesions	No. of DCIS underestimation lesions	DCIS underestimation rates	Statistical significance
Won et al [2]	1999	ST	14G ACNB	154	20	12.9%	7	35%	NS
			11G VAB	236	20	8.4%	3	15%	
Darling et al [3]	2000	ST and ultrasound	14G ACNB	3873	67	7.5%	14	21%	NS[a] $p=0.01$
			14G VAB		47		8	17%	
			11G VAB		175		18	10%	
Schoonjans and Brem [34]	2001	Ultrasound	14G ACNB	424	9	3.7%	5	55.5%	NA
Jackman et al [1]	2001	ST	14G ACNB	13640	373	9.7%	76	20.4%	$p<0.001$
			14, 11G VAB		953		107	11.2%	
Crowe et al [35]	2003	Ultrasound	14G ACNB	832	33	4.0%	17	51.5%	NA
Cho et al [17]	2005	Ultrasound	14G ACNB	562	10	1.8%	5	50%	NS
			11G VAB	417	17	4.0%	7	41%	
Sauer et al [36]	2005	Ultrasound	14G ACNB	962	18	18.7%	11	61.1%	NA
Crystal et al [37]	2005	Ultrasound	14G ACNB	715	6	0.8%	4	66.7%	NA
Londero et al [5]	2007	Ultrasound	14G ACNB	2423	65	2.7%	27	41.5%	NA
Cassano et al [20]	2007	Ultrasound	11G VAB	414	12	3.0%	2	16.7%	NA
Youk et al [23]	2008	Ultrasound	14G ACNB	4359	126	2.9%	36	39%	NA
Current study	2012	Ultrasound	14G ACNB	5061	138	2.7%	66	47.8%	$p<0.001$
			8G,11G VAB	921	56	7.2%	9	16.1%	

ACNB, automated core-needle biopsy; DCIS, ductal carcinoma *in situ*; G, gauge of needle; NA, not applicable; NS, not significant; ST, stereotactic guided; VAB, vacuum-assisted biopsy.
[a]Significant between ACNB and 11G VAB but not between ACNB and 14G VAB.

lesions in Cho et al's study (13.0 mm; range 3–55 mm) for VAB compared with the lesions of our study (mean 11.9 mm; range 5–20 mm in 11-gauge VAB), the acquisition of a larger number of core samples would be better when DCIS is suspected. To our knowledge, our study is the first report that shows a significant difference in the DCIS underestimation rates of ACNB and VAB when using ultrasound guidance.

In our study, a higher DCIS underestimation rate was observed in mass lesions (43.4%) than in microcalcifications (24.5%), which is consistent with the results of previous reports [1, 3, 21]. To determine the relationship between the lesion type and the DCIS underestimation rate, we compared the DCIS underestimation rates of ACNB and VAB in masses and microcalcifications separately. The VAB group had lower DCIS underestimation rates than those of the ACNB group in both masses and microcalcifications. These results show that VAB has an advantage over ACNB in terms of DCIS underestimation with ultrasound guidance, regardless of the lesion type. However, we do not claim that VAB is always the superior choice for mass lesions detected on radiography if the core biopsy is intended for diagnostic purposes and if the lesion has the appropriate size for ACNB.

Indeed, as shown in Figure 2, following standard protocol in our institution, ACNB is a preferred choice for mass lesion with diagnostic purpose, although ultrasound VAB shows better diagnostic accuracy. That is because ACNB itself also shows a high diagnostic accuracy of about 96% [23, 25] and costs less than VAB. However, ultrasound VAB was preferred to ultrasound ACNB in some limited indications that required a larger sampling (*e.g.* in microcalcification visible on ultrasound, heterogeneous lesion and intraductal lesion). In previous studies, VAB showed better accuracy for retrieval of microcalcification than ACNB. Furthermore, when microcalcification is visible on ultrasound, ultrasound guidance has several advantages over ST guidance, such as less patient discomfort from position, a lack of ionising radiation, real-time needle visualisation, multidirectional sampling and lower cost [8, 11–13]. VAB is preferred for heterogeneous lesions on imaging, such as DCIS (suggesting the possibility of heterogeneous pathology [26]), and for intraductal lesions (suggesting the possibility of papillary lesions [27]), as the risk of underestimation in these lesions is considered to be high and large tissue sampling is required. Despite the standard protocol, however, ultrasound ACNB was performed on some cases for reasons such as the patient's economic burden. Although we described some indications for which VAB would be helpful, further study is needed to establish a standard set of indications for VAB.

It has been thought that histological DCIS underestimation is a problem often encountered when microcalcification is biopsied under ultrasound guidance [17, 28–29]. Despite the high percentage of microcalcification lesions in the VAB group, we found a lower DCIS underestimation rate in this group than that in the ACNB group. This finding was probably due to better sampling of lesions with VAB. In ACNB, if air is introduced into the biopsy cavity after the pass of the biopsy needle, the gas in the biopsy track can have a focal echogenic appearance and/or cause shadowing, thereby mimicking or obscuring the original echogenic target. VAB might help to solve this problem because it can suction air and/or blood away from the biopsy cavity during the procedure [13, 30]. Unlike ACNB, the probe is positioned posterior to the lesion so that it does not overshadow (and thereby obscure) the lesion during ultrasound-guided VAB. Consequently, the progress of lesion removal can be monitored in real time in VAB. Furthermore, repositioning of the probe aperture, which

can affect the accuracy of the biopsy results, is not needed in VAB [13, 31]. Finally, one can extract more tissue when using VAB. Therefore, ultrasound VAB would be a better choice for mass lesions with heterogeneous characteristics or intraductal location, or microcalfication lesions visible on ultrasound, especially for the cases in which ST-guided biopsy is not available (*i.e.* when the patient is unable to undergo proper positioning for ST-guided biopsy or if the location of the targeted microcalcification does not permit stereotactic localisation), ultrasound-guided core biopsy may be an effective alternative method, and ultrasound-guided VAB appears to be the superior choice over ACNB.

Our study had several limitations. First, because this was a retrospective study, some degree of selection bias for the use of biopsy devices could not be avoided. To overcome possible selection bias, we compared the DCIS underestimation between two biopsy device groups by lesion type. Second, the high percentage of mass lesions (145 masses and 49 microcalcifications on sonography, and 65 masses and 92 microcalcaifications on mammography) of our study population does not reflect the pattern of previous literature [32–33]. Indeed, we did not analyse the exact percentage of mass lesions out of all biopsied lesions during the study period. Considering that the percentage of lesion type may have an effect on the results of DCIS underestimation, we compared the DCIS underestimation rates of the two groups according to the lesion type to minimise the effects of lesion type on the results. Third, a comparison between ACNB and each VAB probe (8- *vs* 11-gauge) was not performed, because our study was focused on a comparison of the DCIS underestimation rate between ACNB and VAB. Indeed, the cases with 8-gauge and those with 11-gauge had similar clinical and imaging characteristics, and a decision about needle size was largely dependent on the lesion size in this study. Moreover, DCIS underestimations of both needles were not significantly different. Another possible limitation can be the small number of mass lesions with VAB to generalise our results. Finally, data analysis was performed only for the DCIS underestimation rate, not for other outcomes, such as rebiopsy rate or false-negative rate.

In conclusion, the DCIS underestimation rate of ultrasound-guided core biopsies was significantly higher for ACNB relative to VAB. This difference did not change according to the lesion type on sonography. Therefore, ultrasound-guided VAB can be a useful method in the diagnosis of DCIS lesions presented as either mass or microcalcification. However, when deciding which biopsy method is the most effective, many factors should be taken into consideration, including cost, time required for the biopsy, potential complications and the preferences of the clinician and the patient.

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