
ORIGINAL ARTICLE

Sonographic Visibility and Feasibility of Biopsy under Ultrasound Guidance of Suspicious Microcalcification-only Breast Lesions: a Single-centre Study

TE Kim, DB Kim, JH Jung, EK Lee

Department of Radiology, Dongguk University Ilsan Hospital, Goyang-si, Gyeonggi-do, Korea

ABSTRACT

Objectives: To assess the sonographic visibility and feasibility of biopsy under ultrasound guidance of mammographically suspicious microcalcification-only lesions.

Methods: A retrospective review was performed of mammographically detected suspicious microcalcification-only lesions in patients who underwent ultrasound-guided or surgical biopsy between March 2009 and February 2012. The identified microcalcifications were not associated with a mass, architectural distortion or asymmetry on mammography; or a mass, dilated duct, hypoechoic area or microcyst on ultrasound. Microcalcifications were divided into two groups of visible and invisible based on their sonographic visibility. An ultrasound-guided biopsy was performed for the visible group, and mammography-guided localisation and excisional biopsy were conducted for the invisible group. To confirm microcalcification retrieval, radiographs were obtained for all patients. The histological outcomes of the two groups were assessed.

Results: Of the 45 lesions in 44 patients, 22 (48.9%) were in the visible group. Calcifications were retrieved from 21 (95.5%) of the visible group lesions. The malignancy rate was 50.0% (11 of 22; $p = 0.029$) in the visible group and 17.4% (4 of 23) in the invisible group. Among the 10 sonographically visible and one invisible lesion that underwent surgical excision after biopsy, three (30.0%) in the visible group were upgraded pathologically.

Conclusion: The sonographic visibility and retrieval rates of microcalcification-only lesions were 48.9% and 95.5%, respectively. Among the suspicious microcalcification-only lesions, sonographically visible microcalcifications were more likely to be malignant than sonographically invisible microcalcifications.

Key Words: Breast neoplasms; Carcinoma; Mammography; Ultrasonography

中文摘要

乳腺單純微鈣化疑似病變的超聲能見度和超聲引導下穿刺活檢的可行性：一項單中心研究

TE Kim, DB Kim, JH Jung, EK Lee

目的：評估乳腺X線鉬靶片上疑似單純微鈣化病灶的超聲能見度和超聲引導下穿刺活檢的可行性。

方法：回顧分析2009年3月至2012年2月期間因乳腺鉬靶片上疑似單純微鈣化病變而接受超聲引導下穿刺活檢或手術下活檢的病人。經確診的微鈣化與乳腺X線攝影發現的腫塊、結構紊亂或局灶性不對稱無關；超聲發現的腫塊、擴張導管、低迴聲區或微囊腫也無關。微鈣化在超聲下可分為可見和

Correspondence: Dr Dae-Bong Kim, Department of Radiology, Dongguk University Ilsan Hospital, 814 Siksa-dong, Ilsandong-gu, Goyang-si, Gyeonggi-do, 410-773, Korea.
Email: dbkim@dumc.or.kr

Submitted: 5 Sep 2014; Accepted: 1 Dec 2014.

不可見兩組。可見組病例進行超聲引導下穿刺活檢；對不可見組病例則進行乳腺X線攝影引導定位和病灶切除活檢。獲取所有患者乳腺X線片以確認微鈣化的檢出，並評估兩組的組織學結果。

結果：44名患者的45例病變中，22例（48.9%）納入超聲下可見組，其中21例（95.5%）檢出微鈣化。超聲下可見和不可見兩組的惡性腫瘤比率分別為50.0%（22例中的11例； $p = 0.029$ ）和17.4%（23例中的4例）。10例超聲可見和1例超聲不可見的患者在活檢後進行手術切除，超聲可見組中3例（30.0%）病理級別升高。

結論：乳腺單純微鈣化病變的超聲可見度為48.9%，檢出率為95.5%。在疑似單純微鈣化的乳腺病灶中，超聲可見的比超聲不可見的有較高機會屬於惡性病變。

INTRODUCTION

Mammography is a highly sensitive modality for the detection of microcalcifications. However, benign lesions are not always distinguished from malignant lesions. Suspicious microcalcifications have been found to be malignant in 16.9% to 32% of cases.¹⁻⁶ Mammographically detected suspicious microcalcifications, with or without associated findings, are usually histologically confirmed by mammographically guided localisation and excisional or stereotactic needle biopsy.^{5,7-10} Stereotactic needle biopsy is faster and less invasive than excisional biopsy. However, this procedure has several limitations, including patient discomfort, high cost, and lack of universal availability.⁸⁻¹²

Currently, with advances in high-resolution ultrasound (US) equipment using a high-frequency transducer, sonography can depict suspicious microcalcifications with a known mammographic location.¹³⁻¹⁶ Studies have shown that 23% to 97% of microcalcifications were identified as echogenic foci, after careful correlation with mammography results or mammography-guided skin markings.¹⁵⁻¹⁹ In previous studies, sonographically visible microcalcifications were associated with a sonographically depicted mass or dilated ducts of varying degrees (61%-100%).¹⁴⁻¹⁹ According to the Breast Imaging Reporting and Data System (BI-RADS) lexicon, a 'mass' is defined as "a space-occupying lesion seen in two different projections".²⁰ When microcalcifications are located within the hypoechoic mass, the conspicuity of echogenic microcalcifications is enhanced, and confusion associated with anatomical echogenic structures — such as Cooper's ligaments, septa between fat lobules, and the interface of connective tissue — is reduced.^{13,15,21}

Sonographically guided biopsy has traditionally been used for suspicious breast abnormalities, including suspicious masses.^{7,9,22} This procedure has several advantages

over stereotactic biopsy or mammographically guided localisation with excisional biopsy, including minimal patient discomfort and real-time handling of the needle with the scanning probe for ease of use and efficiency. Moreover, the method does not require ionising radiation.^{7,14,23} US can depict microcalcifications without an associated mass, architecture distortion, asymmetry, hypoechoic area, dilated duct or microcysts either on mammography or US, the so-called 'microcalcifications only' lesions. For microcalcification-only lesions, US allows for the possibility of a sonographically guided lesion biopsy.^{17,18} A study of sonographic visibility and US-guided biopsy that is solely composed of patients with microcalcification-only lesions has rarely been described. Therefore, the aim of this study was to assess the sonographic visibility and feasibility of US-guided biopsy of mammographically suspicious microcalcification-only lesions.

METHODS

Patients

All patients attending the Department of Radiology, Dongguk University Ilsan Hospital, Gyeonggi-do, Korea, with suspicious microcalcifications identified during screening mammography underwent US with a spot-compression magnification view. From March 2009 to February 2012, a review of the medical records database identified all women with suspicious breast microcalcification-only lesions who were recommended for biopsy. Only women with biopsied lesions were included. None of the microcalcification-only lesions were palpable. This study and data analysis were approved by the institutional review board.

Categorisation of the Microcalcifications

US of all microcalcifications was performed by one radiologist, who had 6 years of experience in breast imaging, at the beginning of the study. A high-resolution US system (IU22, Philips Medical Systems, Bothell [WA], USA) with a 5- to 12-MHz linear array

transducer was used. All patients were positioned in the supine position with the ipsilateral arm raised above the head. Bilateral whole-breast sonography was performed, with focused examination on the suspected microcalcification area. During the scan, breast compression was minimised at the expected area of the microcalcifications for better detection. Sonographically visible microcalcification-only lesions were defined as echogenic foci that were not traced to echogenic anatomical structures or the echogenic interfaces of connective tissue, and not associated with a mass, dilated duct, hypoechoic area, or microcyst. Sonographic images of these lesions were obtained for two or more planes along the transverse and longitudinal directions. In sonographically visible cases, the operator marked the skin at the shortest distance from the expected lesion location using an oil-based pen. A small round metallic marker was placed at the site of the skin marking. Subsequent spot-compression magnification views (craniocaudal and mediolateral) were performed to match the mammographically detected lesion. In sonographically invisible cases, craniocaudal and mediolateral oblique views of the areas containing microcalcifications were performed. Only two patients did not undergo this procedure.

To determine whether microcalcifications identified in spot-compression magnification views 'matched' the skin marker placed during the following steps, a straight line was drawn tangent to the breast, and another straight line forming a right angle to the previous line from the skin marker to the centre of the breast (like the radius of a circle) was drawn. If any of the microcalcifications were within 1 cm of the second line on both the craniocaudal and mediolateral views, it was considered to be 'matched' and classified as 'visible' (Figure 1). These patients underwent a sonographically guided biopsy (Figure 2). If the position of the marker was more than 1 cm from the microcalcifications, the lesion was classified as 'invisible'. Lesions that were not matched on spot-compression magnification mammography were regarded as sonographic pseudolesions and classified as invisible. These patients underwent mammographically guided wire localisation, followed by surgical excision.

Imaging Analysis

Mammography was performed with one of the two dedicated digital mammography systems (Selenia Full Field Digital Mammography; LORAD, Bedford [MA], USA; Senographe 2000D Full-Field Digital

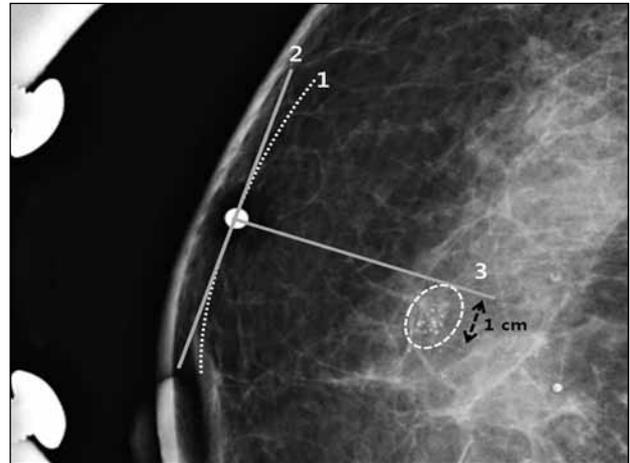


Figure 1. The 'matching' process of mammography and sonographically visualised microcalcification-only lesions. From the skin marker, we drew a curved line parallel to the skin (line 1), then another straight line (line 2) tangent to line 1. Finally, a last straight line forming a right angle to line 2 was drawn (line 3) from the skin marker to the centre of the breast (like the radius of a circle). If any of the microcalcifications were within 1 cm of line 3 on both the craniocaudal and mediolateral/mediolateral oblique views, it was considered to be 'matched' and was classified as 'visible'. If the marker was positioned more than 1 cm from the area, it was classified as 'invisible'.

Mammography System; GE Healthcare, Milwaukee [WI], USA). Routine mammography included standard mediolateral oblique and craniocaudal views. All patients underwent spot-compression magnification mammography for the previously described matching procedure and to evaluate the characteristics of the microcalcification-only lesions. The following mammographic findings of sonographically visible and invisible groups were evaluated and compared: mammographic breast density; extent, distribution, and morphology of microcalcifications; and depth of microcalcifications from the skin. Mammographic breast density was assessed during routine mammography and classified according to the BI-RADS lexicon as predominantly fatty, scattered fibroglandular density, heterogeneously dense, or extremely dense. One patient was excluded from the assessment of breast density because the image was taken at a local clinic and was therefore not available on the picture archiving and communication system of the hospital. Therefore, while the detection of microcalcifications was noted at the time of the ultrasonography, a retrospective review of the image was impossible. The extent of the microcalcifications was determined by the largest diameter from either the mediolateral oblique or craniocaudal view. The distribution and morphology of the microcalcifications were evaluated using spot-

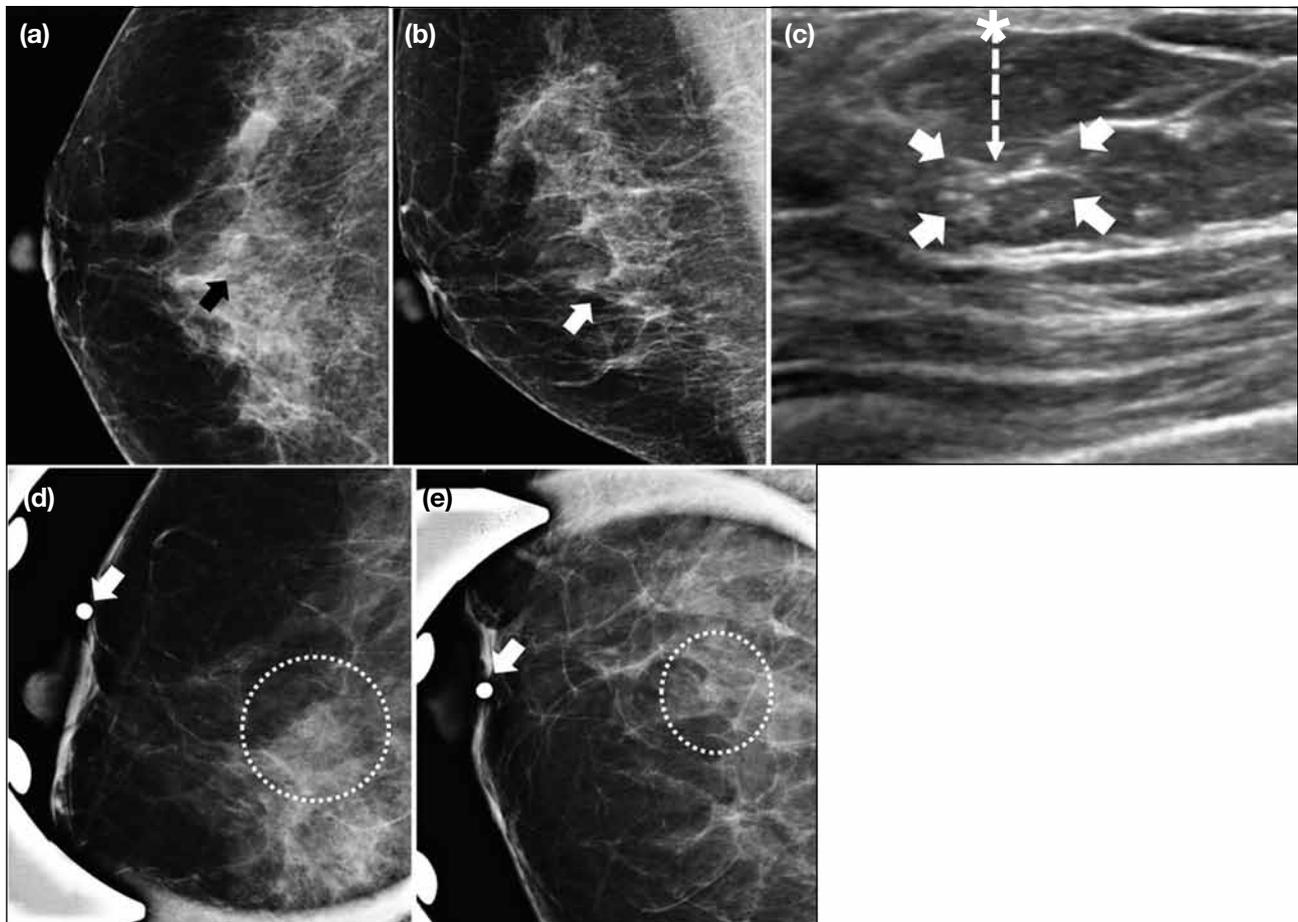


Figure 2. Imaging views of a 64-year-old woman with microcalcifications in the subareolar area of the right breast detected by screening mammography. Initial (a) craniocaudal and (b) mediolateral oblique mammography images show clustered suspicious microcalcifications (arrows) in the central portion of the right breast; (c) sonography image of the subareolar area of the right breast shows a cluster of echogenic foci without associated mass (arrows); the skin was marked (asterisk) with an oil-based pen at the shortest distance from this lesion (dotted line); and (d) and (e) a small round metallic marker (arrows) placed at the site of the skin marking. Magnified mediolateral and craniocaudal mammograms show a cluster of pleomorphic microcalcifications (inside the circle), with the metallic marker (arrows) on the surface near the microcalcifications in these two views. The microcalcifications are regarded as the same lesion as that identified on sonography.

compression magnification and classified according to the BI-RADS lexicon. The microcalcification distribution was described as clustered, linear, segmental, or regional, and the microcalcification morphology was pleomorphic, amorphous, or fine linear branching. The depth of the lesion from the skin was evaluated during the routine mammography. The breast was divided into anterior, middle, and posterior zones by imaginary lines parallel to the skin in both the mediolateral oblique and craniocaudal views. The lesion site was determined by the more superficial zone of the two views, which was only assessed for microcalcifications with a clustered or linear distribution (n = 38). Segmentally and regionally distributed lesions were more widely spread and usually involved more than one zone. The BI-RADS final assessment category

was also recorded based on the mammography and sonography reports. No cases of microcalcifications detected on mammography were associated with a mass, asymmetry, or architectural distortion.

During sonography for the visible group, the extent of the microcalcifications was measured as the largest diameter of the echogenic foci in the transverse, longitudinal, radial, or antiradial view. The lesion depth was measured as the shortest distance from the skin to the group of microcalcifications.

Biopsy Procedure

In the visible group, the microcalcifications were biopsied under US guidance using a 14-gauge coaxial biopsy needle (Stericut; TSK Laboratory, Tochigi,

Japan). In this group, one patient underwent 11-gauge vacuum-assisted biopsy (Mammotome Biopsy System; Ethicon Endo-Surgery, Cincinnati [OH], USA), because the microcalcifications had a clustered distribution, but were quite dispersed. The 14-gauge coaxial biopsy needle was used for all other patients in the visible group because this method was easier to perform and quicker than the 11-gauge vacuum-assisted biopsy. The mean number of biopsy specimens was 5 (range, 3-12). After the biopsy, a specimen mammography was performed to confirm the successful retrieval of microcalcifications. The number of core specimens was recorded.

For the invisible group, mammographically guided wire localisation was performed. Using a fenestrated compression paddle with an alphanumeric grid, a 21-gauge 7.5-cm needle (Accura BLN; Angiotech Pharmaceuticals, Vancouver, Canada) was placed into the microcalcifications, and a hooked wire was placed into the needle. Craniocaudal and mediolateral views were used to verify localisation during the mammography procedure. Surgical excision was performed, followed by specimen mammography to confirm the presence of microcalcifications in the specimen.

Histological Analysis

The histological results from the core and excisional biopsies were reviewed and classified into two categories: benign and malignant. Benign lesions included fibrocystic changes, adenosis, stromal fibrosis, usual ductal hyperplasia, columnar cell hyperplasia, fibroadenoma, atypical ductal hyperplasia (ADH), atypical intraductal proliferative lesion, and mild atypical ductal cells. Malignant lesions included ductal carcinoma in-situ (DCIS), invasive ductal carcinoma, and mucinous carcinoma. Eight patients with histological results of malignancy and three patients with benign results underwent surgery. The biopsy results were correlated with the surgical pathology. Patients with benign histological results underwent a follow-up mammography. We did not separate high-risk lesions, such as ADH, from benign lesions, due to the small number of cases.

Statistical Analysis

Fisher's exact test was used to compare the nominal variables. The Mann-Whitney *U* test was used to compare the continuous variables in the visible and invisible groups. The Statistical Package for the Social Sciences (Windows version 20.0; SPSS Inc, Chicago

[IL], USA) was used for analysis. *p* Values of <0.05 were considered statistically significant.

RESULTS

Patients

From March 2009 to February 2012, review of the medical records database identified 54 suspicious breast microcalcification-only lesions in 53 women (age, 30-69 years; mean age, 47 years) who were recommended for biopsy. Nine patients did not undergo biopsy of the lesion, so they were excluded from the study. In total, 45 lesions in 44 patients were included. None of the microcalcification-only lesions were palpable. Four patients had a history of breast cancer and underwent surgery on the breast ipsilateral (*n* = 2) or contralateral (*n* = 2) to the microcalcification-only lesion.

Categorisation of Microcalcifications

Of the 45 mammographically detected suspicious microcalcifications, 22 (48.9%) were identified during sonography, and were classified as visible (mean age, 46 years; range, 30-69 years); 23 (51.1%) were classified as invisible (mean age, 48 years; range, 30-65 years), with a patient having two lesions. One lesion in the visible group could not be biopsied, because microcalcifications were not identified during the attempted sonographically guided biopsy (Figure 3). A 14-gauge coaxial biopsy was performed for 21 patients in the visible group and one patient underwent an 11-gauge vacuum-assisted biopsy. The microcalcification retrieval rate was 95.5% (21 of 22 lesions) for the visible group and 100% (23 of 23 lesions) for the invisible group. The mean number of days from lesion detection to biopsy was 4.6 for the visible group (range, 0-26 days) and 23.1 for the invisible group (range, 0-95 days; with one outlier at 284 days).

Mammographic Features

The mammographic breast density and the extent, distribution, morphology, and depth of the microcalcifications for the two groups are shown in Table 1. Both groups had similar mammographic features, with no statistically significant differences evident between the groups for the mammographic variables (all *p* > 0.05). All of the segmentally distributed microcalcifications in the visible group were malignant (3/3; 100%), whereas only one malignancy (1/3, 33%) was found in the invisible group. No statistics were applied because the numbers were too small to analyse. The BI-RADS assessment showed statistically significant differences between the two



Figure 3. Imaging views of a 54-year-old woman with a palpable mass in the left breast. (a) Initial mediolateral oblique mammography image with a metallic marker at the palpable site (arrow) shows clustered suspicious microcalcifications (inside the dotted circle) in the upper portion of the left breast; (b) sonography image shows non-palpable multiclustered echogenic foci (arrows) identified as a microcalcification-only lesion at the 11 o'clock position, 6 cm from the nipple; there were three benign-looking nodules at the 7, 9, and 12 o'clock positions in this breast; and (c) a small metallic marker was placed at the expected site of the microcalcifications, and a subsequent mediolateral magnification view of the mammogram shows clustered microcalcifications (inside the dotted circle) near the marker (arrow), which was thought to be 'matched' with the sonographically depicted lesion. This patient underwent sonographically guided biopsy of this lesion, but the lesion was not sonographically delineated during the biopsy, thus, she underwent a mammographically guided needle localisation and excisional biopsy.

Table 1. Mammographic features of microcalcifications.

Mammographic findings	US visible	US invisible	p Value
Breast parenchymal density pattern	(n = 21)	(n = 23)	0.632
Predominantly fatty	0	0	
Scattered fibroglandular density	6 (28.6%)	9 (39.1%)	
Heterogeneously dense	9 (42.9%)	10 (43.5%)	
Extremely dense	6 (28.6%)	4 (17.4%)	
Mean (range) extent of microcalcifications (mm)	22.0 (2.0-78.0)	16.0 (4.1-66.0)	0.386
Distribution of microcalcifications	(n = 22)	(n = 23)	0.698
Clustered	16 (72.7%)	19 (82.6%)	
Linear	2 (9.1%)	0	
Segmental	3 (13.6%)	3 (13.0%)	
Regional	1 (4.5%)	1 (4.3%)	
Morphology of microcalcifications	(n = 22)	(n = 23)	0.131
Amorphous	0	4 (17.4%)	
Pleomorphic	20 (90.9%)	16 (69.6%)	
Fine linear-branching	2 (9.1%)	3 (13.0%)	
Depth of microcalcifications from skin	(n = 18)	(n = 20)	0.247
Anterior	11 (61.1%)	7 (35.0%)	
Middle	6 (33.3%)	12 (60.0%)	
Posterior	1 (5.6%)	1 (5.0%)	

Abbreviation: US = ultrasound.

groups ($p = 0.049$); the visible group had 18 (81.8%) BI-RADS category 4 lesions and four (18.2%) category 5 lesions (highly suggestive of malignancy) and the invisible group had no category 5 lesions, with all lesions being category 4 (100%).

Sonographic Features

In the visible group, the mean extent of the microcalcifications was 10.7 mm (range, 2.4-43.8 mm) and the mean depth of the microcalcifications from the skin was 8.8 mm (range, 3.0-14.1 mm). Of the 22 lesions, 19 (86.4%) were within 10 mm of the skin and

the remaining three (13.6%) were located 10.1 to 20.0 mm from the skin. These two sonographic features of visible microcalcifications were not significantly associated with the histological results (extent, $p = 0.173$; depth, $p = 0.106$).

Histological Outcome

The histological findings revealed malignancy in 11 (50.0%) of 22 lesions in the visible group and four (17.4%) of 23 lesions in the invisible group (Table 2). In the visible group, all of the malignant lesions were DCIS and three of the four malignant lesions in the

invisible group were DCIS (Figure 4), while the one remaining lesion was identified as mucinous carcinoma. In all, 11 (50.0%) of 22 lesions in the visible group and 19 (82.6%) of 23 lesions in the invisible group were benign. In the visible group, 10 (45.5%) patients (7 DCIS, 1 ADH, 1 atypical intraductal proliferative, and 1 mild atypical ductal cells) underwent surgery after the biopsy. Among them, three lesions had upgraded histology on final pathology; one lesion was proven to be malignant on core biopsy (upgraded pathology from DCIS to invasive carcinoma), and two were benign lesions on core biopsies (upgraded pathology from atypical intraductal proliferative lesions and mild atypical ductal cells to DCIS). Finally, 13 (59.1%) lesions in the visible group were proven to be malignant by core biopsy and surgical pathology. In the invisible

group, one (4.3%) lesion was identified as DCIS on mammographically guided wire localisation biopsy and was treated surgically. The biopsy and surgical pathology agreed in this case. Four (18.2%) patients in the visible group and three (13.0%) in the invisible group with biopsy-proven malignant histology did not undergo surgery and were lost to follow-up after biopsy.

Of the 30 (66.7%) biopsy-proven benign lesions, 19 had follow-up studies — five (22.7%) in the visible group and 14 (60.9%) in the invisible group. Two of the five visible group lesions had decreased microcalcifications. The remaining 17 patients had no change in the morphology or extent of the lesion during the follow-up period (range, 6–38 months).

DISCUSSION

Development of high-resolution US has enabled sonographic examination of suspicious breast microcalcifications and guidance of needle biopsy.^{15,24} However, sonography still cannot depict calcifications in some cases. Additionally, some microcalcifications may be missed by US if mammographic findings are not available.^{13,15,25} Moon et al¹⁵ reported that it was reasonable to use US to visualise large (>10 mm) microcalcification clusters. Previous studies have reported a high detection rate of microcalcifications

Table 2. Correlation of US visibility and histological outcome of biopsy specimens.

Histological diagnosis	US visible (n = 22)	US invisible (n = 23)	p Value
Benign lesions	11 (50.0%)	19 (82.6%)	0.029
Malignant lesions*	11 (50.0%)	4 (17.4%)	-

Abbreviation: US = ultrasound.

* All malignant lesions (n = 11) in the visible group and three in the invisible group were ductal carcinoma in-situ. The remaining one lesion in the invisible group was mucinous carcinoma.

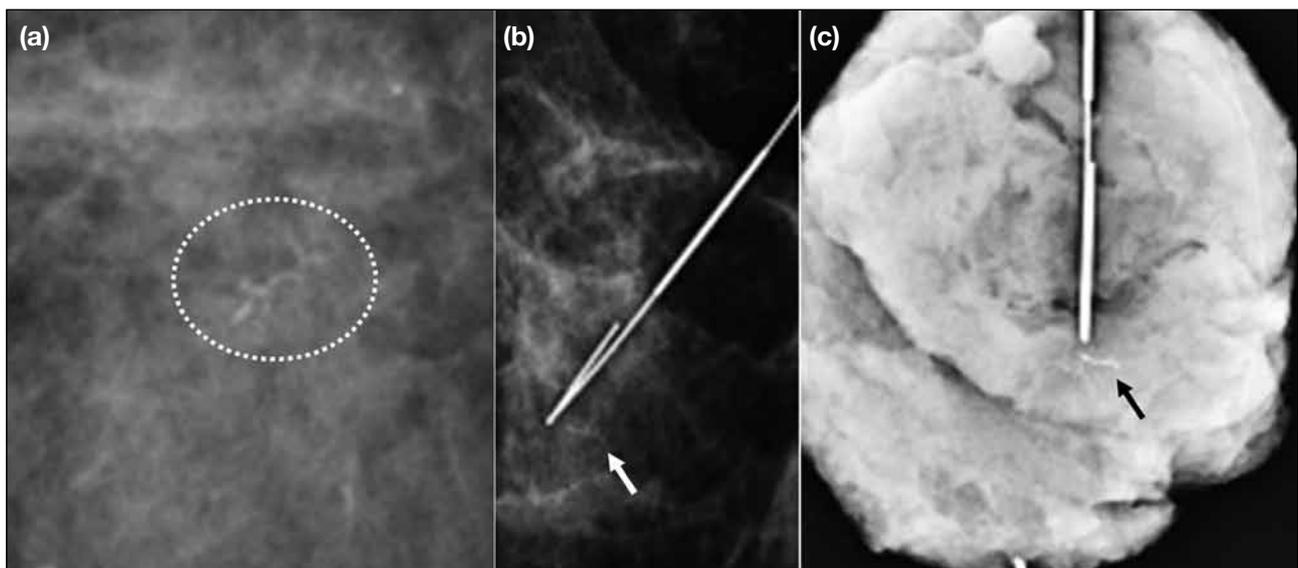


Figure 4. Imaging views of a 45-year-old woman with microcalcifications in the upper portion of the right breast detected by screening mammography. (a) A magnified mediolateral oblique mammogram shows a fine branching-linear distribution of microcalcifications (inside the dotted circle); on ultrasound, these microcalcifications were invisible; (b) the patient underwent mammographically guided needle localisation, and a mediolateral view after the procedure indicates successful localisation of the wire at the site of microcalcifications (arrow); and (c) the specimen radiograph obtained immediately after excisional biopsy shows calcifications (arrow) in the specimen. The pathology revealed ductal carcinoma in-situ.

using sonography (23%-100%); however, these studies included lesions with a coexistent mass or dilated duct.¹³⁻¹⁹ Isolated microcalcifications within normal breast tissue, so-called microcalcification-only lesions, are thought to be more difficult to identify with US due to hyperechoic and heterogeneous background fibrous tissue.²¹ Studies composed of microcalcifications only and their sonographically guided biopsy has rarely been described. In this study, 48.9% of microcalcification-only lesions were identified using sonography.

For isolated microcalcifications on mammographic imaging, calcification retrieval rates of 86% to 100% have been reported with stereotactic-guided 11- or 14-gauge vacuum-assisted or 14-gauge core needle biopsies.^{9,26-29} Several studies have examined sonographically guided biopsy of microcalcification-only lesions. A study by Cho et al¹⁶ indicated the presence of microcalcifications, including microcalcifications only, in 36% of all lesions and reported a calcification retrieval rate of 44% (12 of 27 lesions). In the present study, the retrieval rate by sonographically guided biopsy of the microcalcification-only lesions was 95.5%, which was much higher than that in the previous study. This high success rate could be attributed to the sonographic visibility of microcalcifications in 48.9% of all lesions and the routine performance of the matching procedure for microcalcifications using sonography and mammography. In contrast, in the study of Cho et al,¹⁶ the sonographic visibility of the microcalcifications was 100%, but only 13% of the lesions were confirmed using both sonography and mammography. Thus, the present study may have a slightly lower percentage of pseudolesions identified on sonography compared with the previous study. Cho and Moon¹⁷ and Hahn et al¹⁸ reported retrieval rates of sonographically guided 11-gauge vacuum-assisted biopsies of microcalcifications with or without mass lesions, assisted by mammographically guided skin marking, of 95% and 95.9%, respectively. Our results were similar (95.5%), despite the use of a 14-gauge core needle biopsy for most of the lesions (21 of 22). This is in concordance with the results of the previous study by Cho et al,¹⁶ which showed that core specimen numbers did not affect the likelihood of retrieving calcifications. These authors concluded that accurate targeting is more important than larger sampling volumes. In the present study, microcalcifications lying above the 'hole' of the needle could be verified before firing the 14-gauge semi-automated core needle, therefore, exact targeting of the microcalcifications was

possible. Cho and Moon¹⁷ and Hahn et al¹⁸ categorised the lesions into two groups, as in the present study, of visible and invisible lesions. In their studies, patients were exposed to extra-radiation for mammographically guided skin marking. However, in the present study, most patients underwent sonography first, followed by spot-compression magnification to match and evaluate the lesions. The method to categorise lesions described in the present study minimises the number of mammography procedures, thus reducing radiation exposure. With the high retrieval rate of US-guided biopsy of microcalcification-only lesions, the use of US in sonographically visible microcalcification-only lesions would extend the role of percutaneous US-guided biopsy, particularly for institutions that do not have stereotactic biopsy equipment. Additionally, sonographically visible microcalcification-only lesions are highly suspicious for malignancy compared with invisible microcalcification-only lesions. Thus, when microcalcification-only lesions are visible by sonography, US-guided percutaneous needle biopsy should be highly recommended. If this approach fails, then mammographically guided localisation or stereotactic biopsy should be performed.

No mammographic findings were found to be predictive of the sonographic visibility of microcalcification-only lesions. This is consistent with the results of a previous report.¹⁸ Also, sonographically measured extent and depth of microcalcification-only lesions did not correlate with histological outcome; thus, these parameters should not be used to predict malignancy. Other studies have shown that larger microcalcification clusters, larger numbers of calcification particles, BI-RADS category 5 lesions, and segmentally distributed mammographic lesions were predictive of sonographically visible microcalcifications and associated with a higher percentage of invasive carcinoma.^{13,19}

There are several limitations to this study. First, a single radiologist performed all the US procedures and read all the mammograms. Breast sonography tends to be operator-dependent, thus, the reproducibility of the visualisation of calcifications may vary depending on the skill of the radiologist. To overcome this limitation, mammogram reading followed the BI-RADS. We also added the matching procedure to standardise the sonographic visibility of microcalcification-only lesions. Second, this was a retrospective study, so selection bias could not be avoided. Finally, the pathology of the core biopsy was not always concordant with surgically proven

pathologies. False-negative rates for the US-guided 14-gauge core needle biopsy vary from 1.6% to 3.7%.^{30,31} Soo et al¹⁹ reported a 7% histological underestimation rate by US-guided 14-gauge core needle biopsy (n = 7) and 11-gauge vacuum-assisted needle biopsy (n = 18). False-negative findings may exist in histologically proven benign lesions in this study. Also, the underestimation rate was not calculated due to the small number of patients who underwent surgery.

CONCLUSION

The sonographic visibility of suspicious microcalcification-only lesions was 48.9% in this study. The retrieval rate of US-guided biopsy of these lesions was 95.5%. Sonographically visible microcalcifications were more likely to be malignant when compared with invisible lesions. Thus, US-guided biopsies of sonographically visible microcalcification-only lesions are feasible, and pathological assessment of sonographically visible lesions should be strongly recommended.

REFERENCES

- Bassett LW. Mammographic analysis of calcifications. *Radiol Clin North Am.* 1992;30:93-105.
- Ciatto S, Cataliotti L, Distante V. Nonpalpable lesions detected with mammography: review of 512 consecutive cases. *Radiology.* 1987;165:99-102. [crossref](#)
- Meyer JE, Eberlein TJ, Stomper PC, Sonnenfeld MR. Biopsy of occult breast lesions. Analysis of 1261 abnormalities. *JAMA.* 1990;263:2341-3. [crossref](#)
- Weigel S, Decker T, Korsching E, Hungermann D, Bocker W, Heindel W. Calcifications in digital mammographic screening: improvement of early detection of invasive breast cancers? *Radiology.* 2010;255:738-45. [crossref](#)
- Orel SG, Kay N, Reynolds C, Sullivan DC. BI-RADS categorization as a predictor of malignancy. *Radiology.* 1999;211:845-50. [crossref](#)
- Del Turco MR, Mantellini P, Ciatto S, Bonardi R, Martinelli F, Lazzari B, et al. Full-field digital versus screen-film mammography: comparative accuracy in concurrent screening cohorts. *AJR Am J Roentgenol.* 2007;189:860-6. [crossref](#)
- Parker SH, Burbank F. A practical approach to minimally invasive breast biopsy. *Radiology.* 1996;200:11-20. [crossref](#)
- Elvecrog EL, Lechner MC, Nelson MT. Nonpalpable breast lesions: correlation of stereotaxic large-core needle biopsy and surgical biopsy results. *Radiology.* 1993;188:453-5. [crossref](#)
- Liberman L. Percutaneous image-guided core breast biopsy. *Radiol Clin North Am.* 2002;40:483-500, vi. [crossref](#)
- Liberman L, LaTrenta LR, Van Zee KJ, Morris EA, Abramson AF, Dershaw DD. Stereotactic core biopsy of calcifications highly suggestive of malignancy. *Radiology.* 1997;203:673-7. [crossref](#)
- Cheung YC, Wan YL, Chen SC, Lui KW, Ng SH, Yeow KM, et al. Sonographic evaluation of mammographically detected microcalcifications without a mass prior to stereotactic core needle biopsy. *J Clin Ultrasound.* 2002;30:323-31. [crossref](#)
- Dronkers DJ. Stereotaxic core biopsy of breast lesions. *Radiology.* 1992;183:631-4. [crossref](#)
- Nagashima T, Hashimoto H, Oshida K, Nakano S, Tanabe N, Nikaido T, et al. Ultrasound demonstration of mammographically detected microcalcifications in patients with ductal carcinoma in situ of the breast. *Breast Cancer.* 2005;12:216-20. [crossref](#)
- Soo MS, Baker JA, Rosen EL, Vo TT. Sonographically guided biopsy of suspicious microcalcifications of the breast: a pilot study. *AJR Am J Roentgenol.* 2002;178:1007-15. [crossref](#)
- Moon WK, Im JG, Koh YH, Noh DY, Park IA. US of mammographically detected clustered microcalcifications. *Radiology.* 2000;217:849-54. [crossref](#)
- 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;50:602-9. [crossref](#)
- Cho N, Moon WK. Digital mammography-guided skin marking for sonographically guided biopsy of suspicious microcalcifications. *AJR Am J Roentgenol.* 2009;192:W132-6. [crossref](#)
- Hahn SY, Shin JH, Han BK, 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;52:29-34. [crossref](#)
- Soo MS, Baker JA, Rosen EL. Sonographic detection and sonographically guided biopsy of breast microcalcifications. *AJR Am J Roentgenol.* 2003;180:941-8. [crossref](#)
- Breast Imaging Reporting and Data System Atlas. The American College of Radiology; 2003.
- Gufler H, Buitrago-Téllez CH, Madjar H, Allmann KH, Uhl M, Rohr-Reyes A. Ultrasound demonstration of mammographically detected microcalcifications. *Acta Radiol.* 2000;41:217-21. [crossref](#)
- Liberman L, Feng TL, Dershaw DD, Morris EA, Abramson AF. US-guided core breast biopsy: use and cost-effectiveness. *Radiology.* 1998;208:717-23. [crossref](#)
- Parker SH, Jobe WE, Dennis MA, Stavros AT, Johnson KK, Yakes WF, et al. US-guided automated large-core breast biopsy. *Radiology.* 1993;187:507-11. [crossref](#)
- Anderson ME, Soo MS, Bentley RC, Trahey GE. The detection of breast microcalcifications with medical ultrasound. *J Acoust Soc Am.* 1997;101:29-39. [crossref](#)
- Lambie RW, Hodgden D, Herman EM, Kopperman M. Sonomammographic manifestations of mammographically detectable breast microcalcifications. *J Ultrasound Med.* 1983;2:509-14.
- Liberman L, Evans WP 3rd, Dershaw DD, Hann LE, Deutch BM, Abramson AF, et al. Radiography of microcalcifications in stereotaxic mammary core biopsy specimens. *Radiology.* 1994;190:223-5. [crossref](#)
- Liberman L, Hann LE, Dershaw DD, Morris EA, Abramson AF, Rosen PP. Mammographic findings after stereotactic 14-gauge vacuum biopsy. *Radiology.* 1997;203:343-7. [crossref](#)
- Meyer JE, Smith DN, DiPiro PJ, Denison CM, Frenna TH, Harvey SC, et al. Stereotactic breast biopsy of clustered microcalcifications with a directional, vacuum-assisted device. *Radiology.* 1997;204:575-6. [crossref](#)
- Reynolds HE, Poon CM, Goulet RJ, Lazaridis CL. Biopsy of breast microcalcifications using an 11-gauge directional vacuum-assisted device. *AJR Am J Roentgenol.* 1998;171:611-3. [crossref](#)
- Crystal P, Koretz M, Shcharynsky S, Makarov V, Strano S. Accuracy of sonographically guided 14-gauge core-needle biopsy: results of 715 consecutive breast biopsies with at least two-year follow-up of benign lesions. *J Clin Ultrasound.* 2005;33:47-52. [crossref](#)
- Schueller G, Jaromi S, Ponhold L, Fuchsjaeger M, Memarsadeghi M, Rudas M, et al. US-guided 14-gauge core-needle breast biopsy: results of a validation study in 1352 cases. *Radiology.* 2008;248:406-13. [crossref](#)