



The role of contrast-enhanced spectral mammography in the evaluation of the postoperative breast cancer

M.H. Helal^a, S.M. Mansour^{b,*}, H.A. Ahmed^c, A.F. Abdel Ghany^c,
O.F. Kamel^c, N.G. Elkholy^d

^a Department of Radiology, Women's Imaging Unit, National Cancer Institute, Cairo University, Cairo, Egypt

^b Department of Radiology, Women's Imaging Unit, Kasr ElAiny Hospital, Cairo University, Cairo, Egypt

^c Department of Radiology, Ain Shams University, Abbasyia, Cairo, Egypt

^d Department of Radiology, Women's Imaging Unit, Ain Shams University, Abbasyia, Cairo, Egypt

ARTICLE INFORMATION

Article history:

Received 29 November 2018

Accepted 5 June 2019

AIM: To assess the utility of contrast-enhanced spectral mammography (CESM) to detect malignancy in the postoperative breast of cancer patients.

MATERIALS AND METHODS: The study was a prospective analysis of 76 women following operations for breast cancer. CESM was performed with low (22–33 kVp) and high (44–49 kVp) energy exposures after intravenous injection of contrast agent. Breast abnormalities were evaluated regarding the presence, morphology, and pattern of contrast medium uptake. The reference standard was histopathology of the Tru-Cut biopsy or surgical biopsy in cases where malignancy was suspected and absence of abnormality at follow-up sessions in benign cases.

RESULTS: Seventy cases were eligible for data analysis, and malignancy was detected in 48.6% ($n=34/70$). Enhancement at the operative bed was observed in 40 (57.14%) lesions. At traditional mammography, the diagnosis was false negative in 17/70 and false positive in 28/70 lesions, and presented a low sensitivity of 50%, a very low specificity of 22%, a positive predictive value of 37.7%, a negative predictive value of 32%, and an accuracy of 35.7%. CESM enhanced the performance of mammography and produced a sensitivity of 91.17%, a specificity of 75%, a positive predictive value of 77.5%, a negative predictive value of 90%, and an accuracy of 82.85%.

CONCLUSION: CESM is a credible technique that could be used in conjunction with the traditional mammogram to screen for cancer in the postoperative breast.

© 2019 The Royal College of Radiologists. Published by Elsevier Ltd. All rights reserved.

Introduction

Scanning of the postoperative breast represents an imaging dilemma as there is an overlap between the features of accepted benign post-treatment alterations and pre-existing cancer. After lumpectomy and radiation therapy, changes such as seromas, breast oedema, dermal

* Guarantor and correspondent: S. M. Mansour, Department of Radiology, Women's Imaging Unit, National Cancer Institute, Cairo University, Cairo, Egypt. Tel.: +1006029047.

E-mail address: sahar_mnsr@yahoo.com (S.M. Mansour).

thickening, focal distortion, and calcifications, are not easily discriminated from recurrent breast carcinoma and this could lead to unnecessary recall on screening.¹

The sensitivity of mammography to enable detection of breast cancer varies widely. Several studies have stated that in breasts with dense parenchyma, the sensitivity of mammography to detect tumours may be as low as 30–48%.² As part of the routine follow-up of the postoperative breast, ultrasound is a useful complement to mammography. For most symptomatic patients, ultrasound is considered to be an effective diagnostic technique, but in asymptomatic patients, ultrasound may not be undertaken, and consequently, the diagnosis would be delayed.

Contrast medium-based imaging methods can be used to detect abnormal vasculature due to tumour neoangiogenesis and so provide helpful information in the diagnosis of breast cancer.³ The low-energy image elicited at contrast-enhanced spectral mammography (CESM) is comparable to a regular mammogram, and when combined with the high-energy image, the enhancing structures within the breast tissue can be detected easily.⁴ CESM may aid in minimising cases with positive margins (i.e., cancer cells found in the margins of the excised specimen) at the operative bed and in detecting tumour recurrence.⁵

As postoperative/therapy inflammation and tissue oedema may take up to 6 months to resolve, cancer is considered recurrent if it appears after at least 1 year of full recovery. Yet, the duration required to detect postoperative re-appearance of the breast cancer is not standard and there are subtypes of breast cancers that show early relapse, such as basal-like and Her2-enriched breast cancers. Therefore, the present study was undertaken to screen for developing cancer in the postoperative duration between 6 months up until 1 year, as at this stage, the residual/recurrent cancer may be confused with the benign changes. The aim of the study was to assess the role of CESM in detecting malignancy in the postoperative breast of cancer patients. The ability of CESM to differentiate between benign interventional complications and early local/regional recurrence of breast cancer was assessed.

Materials and methods

This study was an analysis of prospective work that was approved by the ethics committee of the Scientific Research Review Board of the Radiology Department at National Cancer Institute, Cairo, Egypt. Patients gave informed consent to be included in the study.

Patients

The current work included 76 postoperative cases of proven breast cancer. Cases were evaluated during May 2015 to October 2017. Cases were examined at a single institute (Women's Imaging Unit, National Cancer Institute), which is a specialised centre for the detection, staging, surgery, and therapy of breast cancer.

Inclusion criteria

Inclusion criteria for the study included suspicious abnormalities of the postoperative breast as reported in the preliminary mammogram as (1) mass lesions, (2) developing areas of parenchymal distortion, (3) developing focal asymmetry, and (4) suspicious microcalcifications. Patients with postoperative dense breast tissue due to therapy/surgery changes in the presence of a clinical indication and mammograms of low sensitivity (i.e., dense breasts, BI-RADS zero) underwent CESM to enhance the sensitivity of conventional mammography and exclude residual/recurrent malignancy. Patients received neoadjuvant chemotherapy (8 cycles) preoperatively and radiotherapy immediately after surgery.

Exclusion criteria

Exclusion criteria included (1) patients with renal insufficiency, (2) patients with contrast agent allergy, (3) pregnant or possibly pregnant patients, (4) patients that were <6 months into the postoperative period as false-positive results may be obtained.

Imaging

Two views were taken for each breast: mediolateral oblique (MLO) and craniocaudal (CC) positions. The position of the patient and the CESM technique were not different from those of the conventional mammogram. CESM was performed using the Senographe Essential full-field digital mammography system (GE Healthcare, Chalfont St-Giles, UK). The technique commenced by inserting a cannula in the antecubital fossa on the opposite side of the affected breast. A qualified technologist injected non-ionic contrast medium intravenously (1.5 ml/kg body weight) just before compression of the breasts. The degree of compression varied according to breast tissue thickness (30–80 mm) and was applied for all positions, with sufficient pressure to limit breast motion but not reduce blood flow. Two minutes after the initiation of the contrast medium injection, another set of bilateral CC and MLO views were acquired. The order of imaging was the CC view of the unaffected breast followed by the CC and the MLO views of the affected breast; and then the MLO view of the unaffected breast.

CESM was performed by acquiring a pair of low- and high-energy images in quick succession during a single breast compression. Low-energy images were acquired at peak kilovoltage with values ranging from 26–31 kV, which is below the K-edge of iodine at 33.2 keV. High-energy images were acquired at 45–49 kV, which is above the K-edge of iodine. The duration of the technique ranged between 6–8 minutes.

Image analysis was done on an Image Diagnostic Mammography Workstation (GE Healthcare). Post-processing subtraction of the two images was performed to generate contrast-enhanced images and reduce the visibility of the background enhancement of the breast parenchyma. The subtraction post-contrast images were used

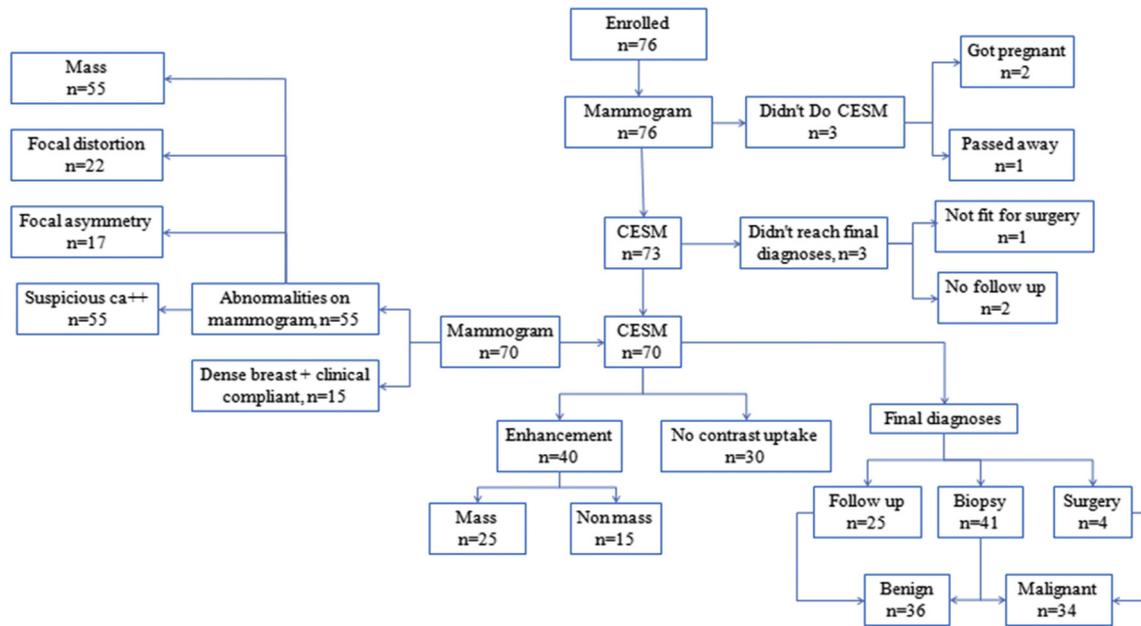


Figure 1 A flow chart of the study.

for the assessment of the lesions that were detected in the breast after surgery.

Interpretation was performed by three radiologists/readers who are experts in breast imaging and intervention. Two readers (with 30 and 20 years of experience) undertook the initial evaluation blindly from the findings of the CESM and the third reader (with 35 years of experience) confirmed the diagnosis of one or two of the other readers in cases of mismatched results.

Table 1 Final diagnosis of the included postoperative breast lesions.

Final diagnosis	n	%	
Pathology proven	Invasive ductal carcinoma	24	34.3
	Ductal carcinoma in situ	5	7.1
	Invasive lobular carcinoma	4	5.7
	Mucinous carcinoma	1	1.4
	Fibroadenoma	3	4.3
	Fibroadenosis	2	2.9
	Fat necrosis	6	8.6
	Regression of the abnormality and presumed benign	25	35.7
Follow-up cases	25	35.7	
Total	70	100	

Table 2 Correlation between pathology and enhancing lesions on contrast-enhanced spectral mammography.

		Pathology						Chi-square	
		Benign		Malignant		Total		X ²	p-Value
		n	%	n	%	n	%		
Enhancement	No	TN	26	74.3	FN	4	11.4	30.63	<0.001
		FP	9	25.7	TP	31	88.6		
	Yes	5	50	20	67	25	62.5		
Types of contrast medium uptake	NM	5	50	10	33	15	37.5		

When a breast lesion was enhancing, the descriptive criteria were either contrast uptake of a mass or non-mass. Mass enhancement was characterised in the form of shape (regular, irregular), margin (circumscribed, ill-defined, spiculate), and internal mass enhancement characteristics (homogeneous, heterogeneous, and rim).

Data from the histopathology report were considered the reference standard based on the Tru-Cut biopsy (14 G needle)/surgical biopsy in cases where malignancy was suspected.

Cases that showed an absence of abnormal contrast medium uptake on CESM were subjected to another 6-months interval follow-up examination. Benign pathology was noted if the abnormality followed a regressive course on follow-up. Conversely, cases that showed suspicion of malignancy were subjected to Tru-Cut biopsy (14 G needle)/surgical biopsy and the diagnosis noted in the histopathology report was considered the standard of reference.

Statistical analysis

The diagnostic indices (sensitivity, specificity, positive and negative predictive, and accuracy values) were

calculated for mammography and CESM. Data were described statistically in terms of frequencies and percentages. Comparison between the patterns of contrast medium uptake was done using the chi-square test. The exact test was used instead when the frequency was <5. A *p*-value of <0.05 was considered statistically significant. The overall performance of CESM was evaluated. All statistical calculations were performed using the computer program, SPSS (Statistical Package for the Social Science; SPSS, Chicago, IL, USA) version 15 for Microsoft Windows.

Results

The study included 76 patients with breast cancer who were examined using digital mammography and CESM to confirm or exclude the presence of recurrence (Fig 1). Six cases were excluded: two patients became pregnant before undergoing CESM, one patient died, another had medical reasons not to undergo a second surgery, and two patients were lost to follow-up. As a result, 70 patients were eligible for data analysis and they underwent the following surgical procedures: conservative (*n*=42; lumpectomies and quadrantectomies), reconstructive (*n*=23; autologous tissue or prosthetic implant), and nipple-sparing mastectomy (*n*=5).

A relapse of malignancy was noted in 48.6% (*n*=34/70) of the included cases, which was proved by either Tru-Cut biopsy (*n*=30) or surgery (*n*=4). Benign diagnoses were present in 51.4% (*n*=36/70) of the cases. Eleven lesions (30.6%) were histopathologically proven. In the remaining cases (25/36; 69.4%), benign pathology was suggested on regression of the breast abnormality at follow-up CESM.

Mammograms showed a mass lesion in 11.43% (*n*=8/70), focal distortion in 31.43% (*n*=22/70), focal asymmetry in 24.28% (*n*=17/70), suspicious calcifications in 11.43% (*n*=8/70), and no abnormality in 21.43% (*n*=15/70).

At CESM, enhancement was observed in 57.14% (*n*=40/70) of the included breasts of which 62.5% (*n*=25/40) were “mass” and 37.5% (*n*=15/40) were “non-mass” lesions. Twenty-five cases showed enhancing masses. By shape, 12/25 (48%) of the lesions were of regular and 13/25 (52%) were of irregular shape. Regarding margins, 5/25 (20%) showed circumscribed, 12/25 (48%) showed ill-defined, and 8/25 (32%) showed spiculate margins. Regarding patterns of internal enhancement, the majority of cases (*n*=16/25, 64%) showed heterogeneous contrast medium uptake. Homogeneous contrast medium uptake was noted in 32% (*n*=8/25) of the lesions and only one mass (4%) showed the “rim” pattern of enhancement. A non-mass-like pattern of contrast uptake noted in 15 cases: the distribution was regional in 60% (*n*=9/15), segmental in 20% (*n*=3/15), and linear in another 20% (*n*=3/15). The pattern of contrast uptake was homogeneous in one case (6.6%), heterogeneous in 66.7% (*n*=10/15), and clumped in 26.7% (*n*=4/15).

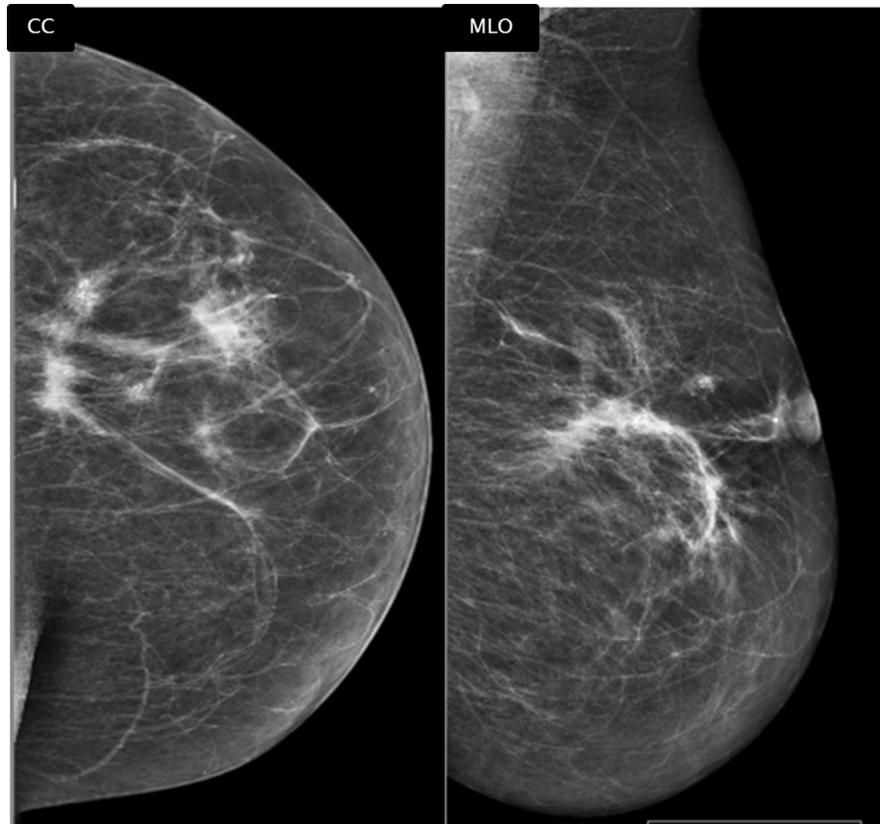
The final histopathological correlation and follow-up revealed malignancy in 48.6% (*n*=34/70) of the cases. Benign findings of fibrofatty tissue, scarring, and giant cell reaction were found in 35.7% (*n*=25/70), and benign masses were detected at the operative bed in 15.7% (*n*=11/70; Table 1). Out of the 40 enhancing lesions, 31 lesions (77.5%) were found to be of malignant nature. Table 2 demonstrates the correlation between the findings at histopathology and the enhancing lesions that were detected on the CESM. Table 3 shows the correlation between the opinion based on

Table 3
Correlation between the mammography findings and the pathological diagnosis.

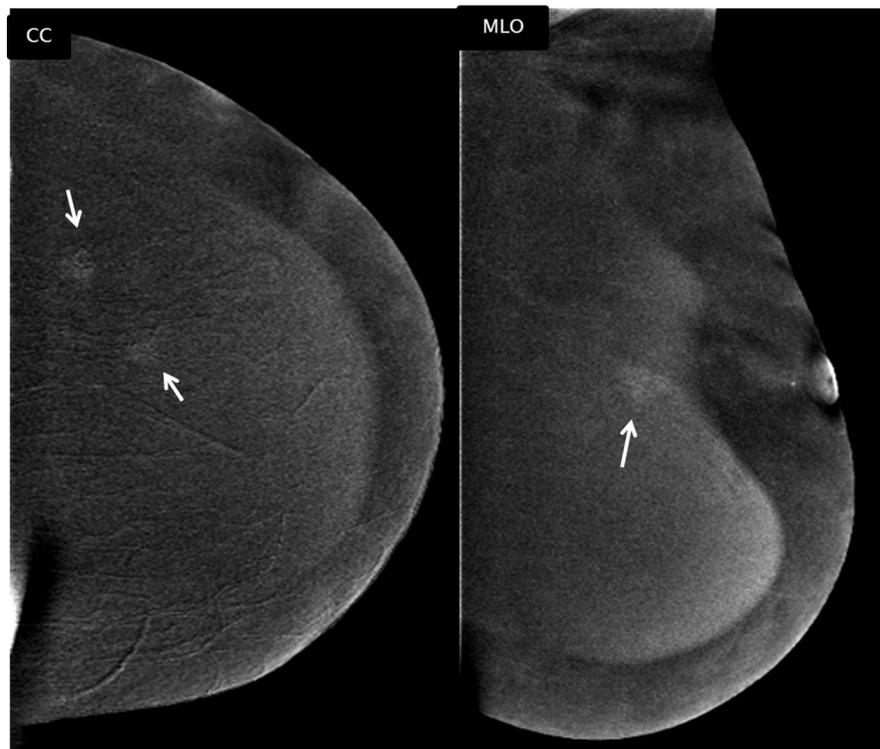
Mammography	Pathology						Chi-square	
	Benign		Malignant		Total		X2	p-Value
	N	%	n	%	n	%		
Negative	8	22.2	17	50	25	35.7	5.73	0.017
Positive	TN		FN					
	28	77.8	17	50	45	64.3		
Total	36	100	34	100	70	100		
Sensitivity	Specificity		PPV		NPV		Accuracy	
50	22.22		37.7		32		35.7	

Table 4
Correlation of contrast-enhanced spectral mammography (CESM) findings and pathological diagnosis.

CESM	Pathology						Chi-square	
	Benign		Malignant		Total		X2	p-Value
	N	%	N	%	N	%		
Negative	27	75	3	8.82	30	42.86	30.630	<0.001
Positive	TN		FN					
	9	25	31	91.18	40	57.14		
Total	36	100	34	100	70	100		
Sensitivity	Specificity		PPV		NPV		Accuracy	
91.17	75		77.5		90		82.85	



(a)



(b)

Figure 2 A 42-year-old female patient who underwent left conservative breast surgery (CBS) who present for her regular follow-up. (a) Digital mammogram, left breast CC and MLO views showed heterogeneous indistinct densities related to the operative bed (upper central, 12 o'clock; BI-RADS 3). (b) CESM showed two enhancing masses (overlapped in MLO view) of irregular shape with spiculate margins (arrows) at the operative bed (BI-RADS 5). The case was a true positive and proved to be invasive ductal carcinoma grade II at histopathology.

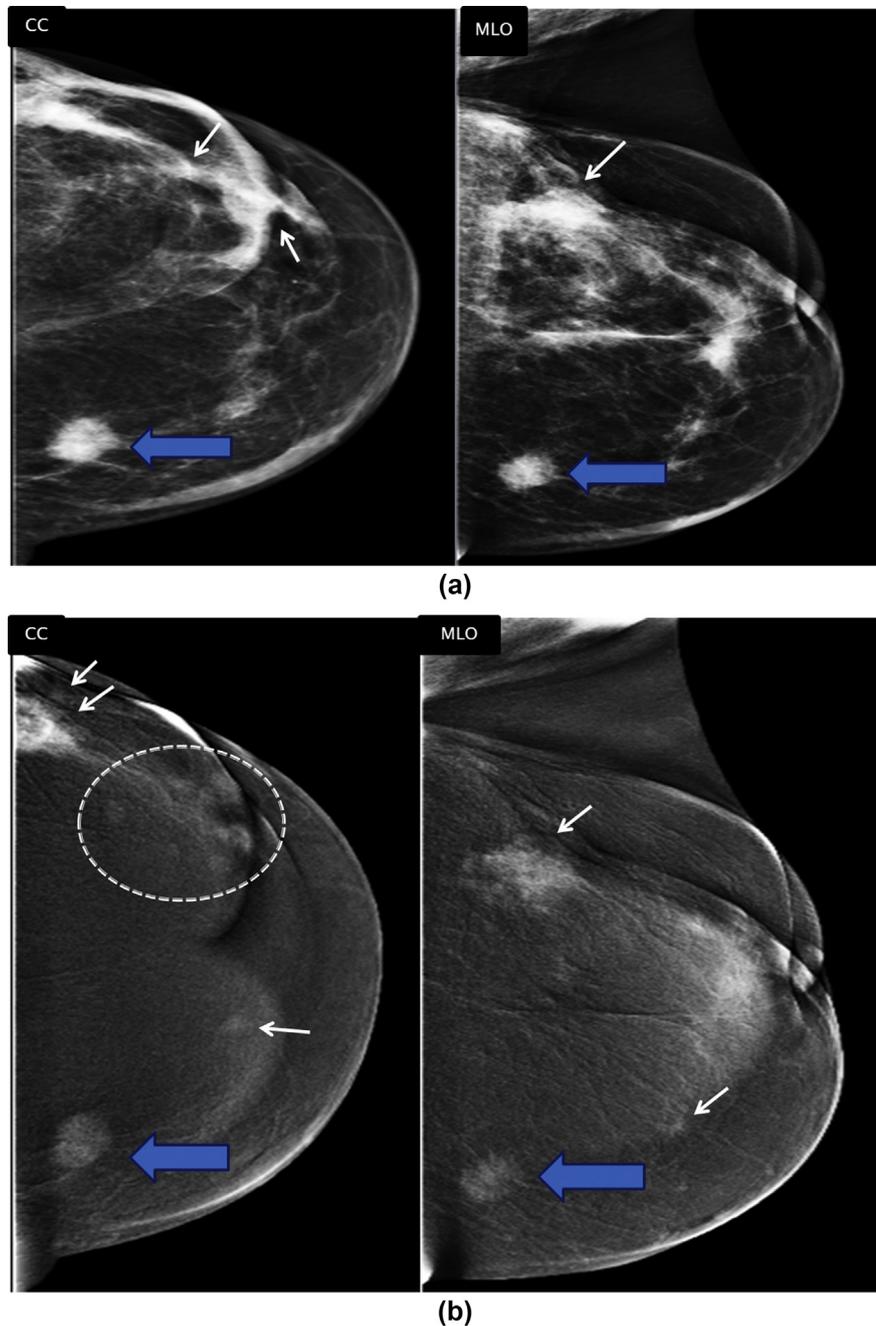


Figure 3 A 53-year-old female patient who underwent left CBS (Her2 enriched subtype of breast cancer) 1 year ago, and recently presented with a newly developed palpable lower inner quadrant lump. (a) Traditional digital mammograms in CC and MLO views showed a malignant-looking mass with spiculate margin (thick arrow) in the lower inner quadrant. In addition, there were suspicious densities at the operative bed (small arrows; BI-RADS 5). (b) CESM confirmed the diagnosis of the lower inner mass and revealed multiple enhancing foci and upper outer non-mass enhancement that was tracing the scar line (BI-RADS 5). CESM not only confirmed the diagnosis of malignancy but also displayed a more extensive distribution of the disease (multicentric invasive ductal carcinoma).

the mammograms and the final diagnoses: 17 lesions were true positives, 28 lesions were false positive, 17 lesions were false negatives, and eight lesions were true negatives. Upon correlating the diagnoses based on the CESM to that of the histopathology diagnoses (Table 4), 31 lesions were true positive, nine lesions were false positive, 27 were true negative, and three lesions were false negative. Accordingly, CESM showed a sensitivity of 91.17%, a specificity of 75%, a

positive predictive value of 77.5%, a negative predictive value of 90%, and accuracy of 82.85%.

Discussion

Women with a history of breast cancer are at increased risk of developing local recurrences, contralateral breast cancer, or other primary ipsilateral breast cancer. Breast-

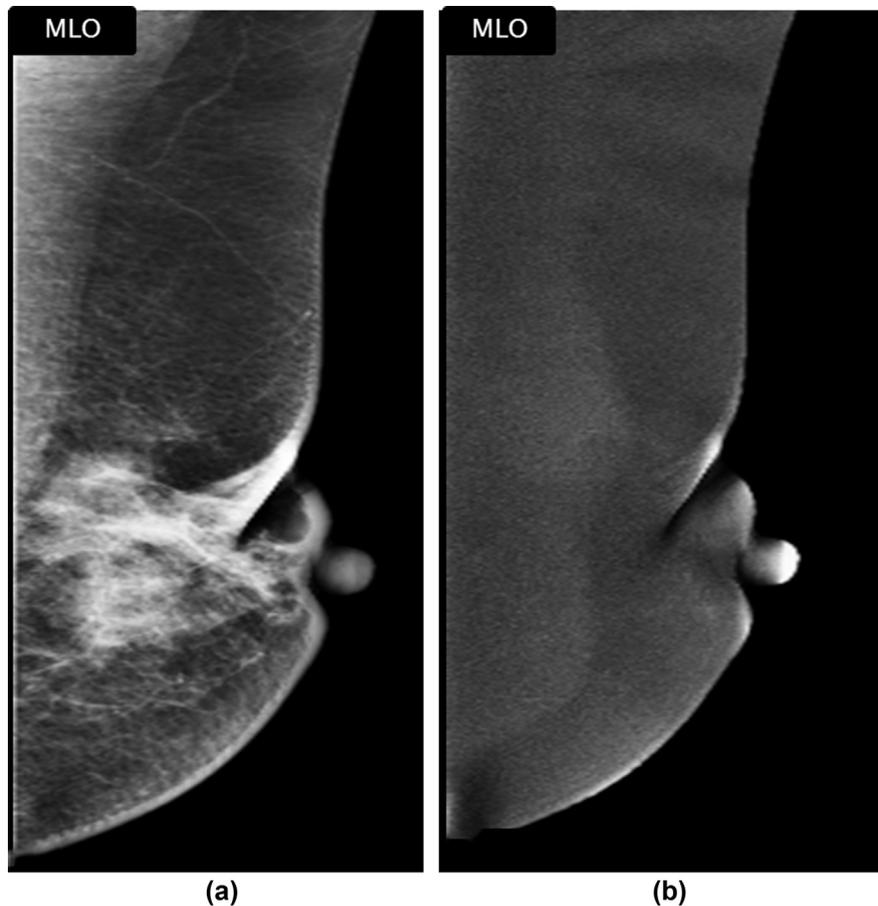


Figure 4 A 50-year-old female patient who underwent left CBS. A: traditional digital mammogram MLO view showed the operative bed focal area of increased density (BI-RADS 3). B: CESM revealed no enhancing foci or masses and no “non-mass” enhancement as well (BI-RADS 1). The case was considered true negative upon CESM basis.

conservative surgery is the choice for stage I and II breast cancer. One study reported no significant difference in the survival rates between patients that underwent breast-conservative surgery and those that underwent mastectomy.⁶ Long-term survival is dramatically improved with early detection of local recurrence of breast cancer.⁷

CESM is a contrast-based mammogram that combines the imaging technique of the digital mammogram but with increased sensitivity. In the present study, the impact of using CESM to assess the operative bed in patients proven to have breast cancer was assessed. The present cohort of patients was imaged between 6 months and a year following surgery. Detection of cancerous cells at this early follow-up interval would tend to indicate residual rather than the recurrence of cancer; however, the margins of the resection specimens from each patient were free from cancer cells, and so, in the present study, cancers detected in the operative bed can be considered to be recurrent.

The use of breast reconstruction post-cancer became more prevalent during the study period, and so readers also had to recognise the abnormal imaging findings resulting from breast conservation and reconstruction surgeries and differentiate these from malignancy.

There are few studies in the literature regarding this field and such an approach has not yet been attempted in the clinical application. Thus, discussion of the use of the CESM as a potential imaging technique in the follow-up of patients after breast surgery will be in reference to the literature.

According to the 5th edition of the American College of Radiology (ACR) Breast Imaging-Reporting and Data System (BI-RADS) atlas, there is a well-defined and standardised lexicon of morphology descriptors to characterise breast lesions on DCE-MRI; however, there is no similar lexicon for CESM and so a standardised lexicon of morphology descriptors for CESM should be devised.⁸ As both CESM and MRI breast imaging methods are contrast medium based, the morphology descriptors of MRI were used in the present study to describe the features of the postoperative breast on the CESM images.

The mammography findings were compared with the pathology findings resulting in 17 true positive, and eight true negative lesions. The regular digital mammogram produced a high number of false positive cases ($n=28$) in comparison to the CESM which produced only nine false positive results. This could be attributed to the presence of

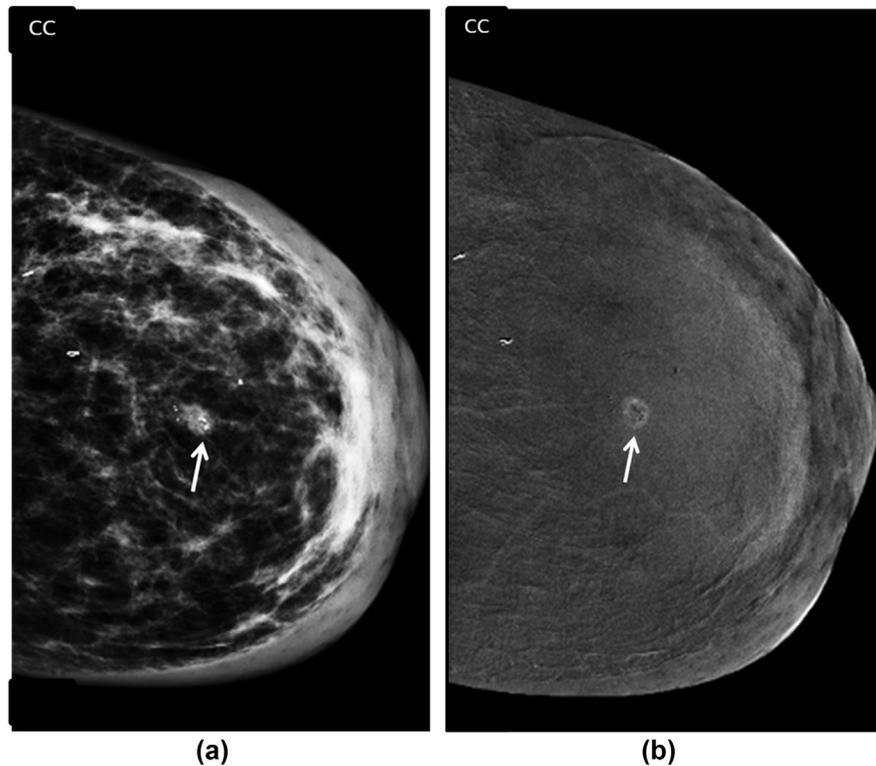


Figure 5 A 47-year-old female patient who underwent left CBS 1 year ago and presented with a complaint of left breast hardness and “peau d’orange” changes of the skin. (a) Digital mammogram of the left breast in CC view revealed marked oedematous changes in the form of diffuse circumferential skin thickening and coarsened trabeculation, suggestive of recurrence. There was also an upper central (12 o’clock) tiny suspicious mass (arrow) with partly indistinct borders and internal microcalcifications (BI-RADS 4). (b) The upper central mass was evident at CESM, yet here it showed a circumscribed border, faint contrast uptake, and lucent centre, suggestive of a calcified benign mass. No trabecular or dermal enhancement. CESM downgraded the category from BI-RADS 4 to 2 and the mass proved to be fat necrosis.

architectural distortion and increased breast density at the lumpectomy site and post-treatment oedema on the regular mammogram. False negative cases ($n=17$) were lesions masked by condensed breast tissue which were not visualised on the mammogram.

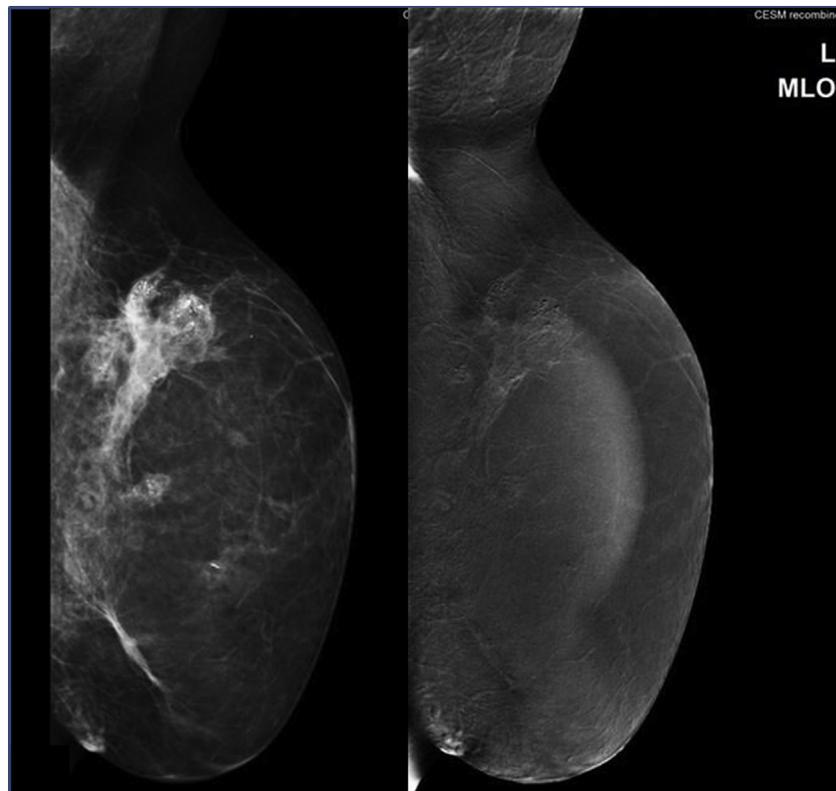
The low diagnostic indices in the current work were in accordance with Yalcinkaya *et al.*, who concluded that assessment of the breast is not easily achieved using mammography and they suggested that ultrasound was a better method in patients with a history of conservative breast surgery and/or radiotherapy as tissue distortion and oedema will be present. In addition, they recommended a contrast-based imaging tool to be the chosen method of screening patients at high risk of breast cancer.⁹

As CESM is a contrast medium-based breast study, it was used in the present study as a replacement for MRI, to obtain information regarding patterns of enhancement and the behaviour of contrast medium uptake in breast lesions. Enhancement was observed at CESM in 40 lesions (57.14%), which resulted in a malignant diagnosis if abnormal contrast medium uptake was detected at the operative bed with the following morphological features: irregular shape, irregular or spiculate margins, and heterogeneous or rim pattern of contrast medium uptake (Figs 2 and 3).

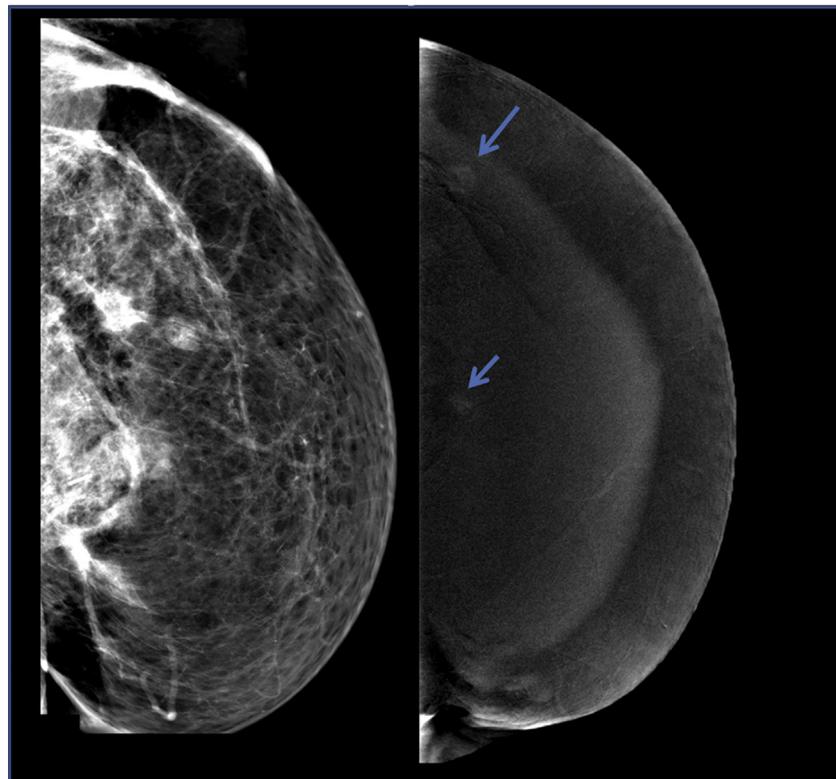
A benign diagnosis was mainly based on the absence of contrast medium uptake (Fig 4). In addition, benign morphology descriptors were considered for enhancing masses with rounded or oval shapes, circumscribed margins, and a homogeneous pattern of enhancement (Fig 5).

Nine false positive cases were noted upon comparison of the CESM diagnoses to the histopathology results. These cases were misdiagnosed due to the detection of enhancement at the operative bed, but were caused by benign postoperative changes. Of the nine cases, three false positive cases were irregular masses that had well-circumscribed margins but a heterogeneous pattern of enhancement, which proved to be benign (fibroadenoma) on histopathology; three cases with non-mass enhancement that was highly suspicious of relapsing malignancy and a diffuse pattern of tissue oedema, skin thickening, and coarse trabeculae of the breast, which proved to be fat necrosis and were negative for cancer cells at the lumpectomy bed; and the remaining three cases showed non-mass enhancement at the site of the operative bed and proved to be changes associated with benign adenosis.

This was in accordance with Chae *et al.*, who hypothesised that non-specific contrast medium uptake could be seen at the operative bed for up to 6 months post-procedure



(a)



(b)

Figure 6 Two cases of reconstructive breast surgeries using transverse rectus abdominis myocutaneous (TRAM) flaps. (a) One case showed focal distortion and suspicious calcific clusters along the operative bed on the conventional mammogram yet no abnormal contrast medium uptake was noted in the contrast-based study. Biopsy revealed fat necrosis. (b) The second case showed multiple focal indistinct densities at the scar line that displayed suspicious enhancement at CESM (arrows) and proved to be a recurrence of the malignancy.

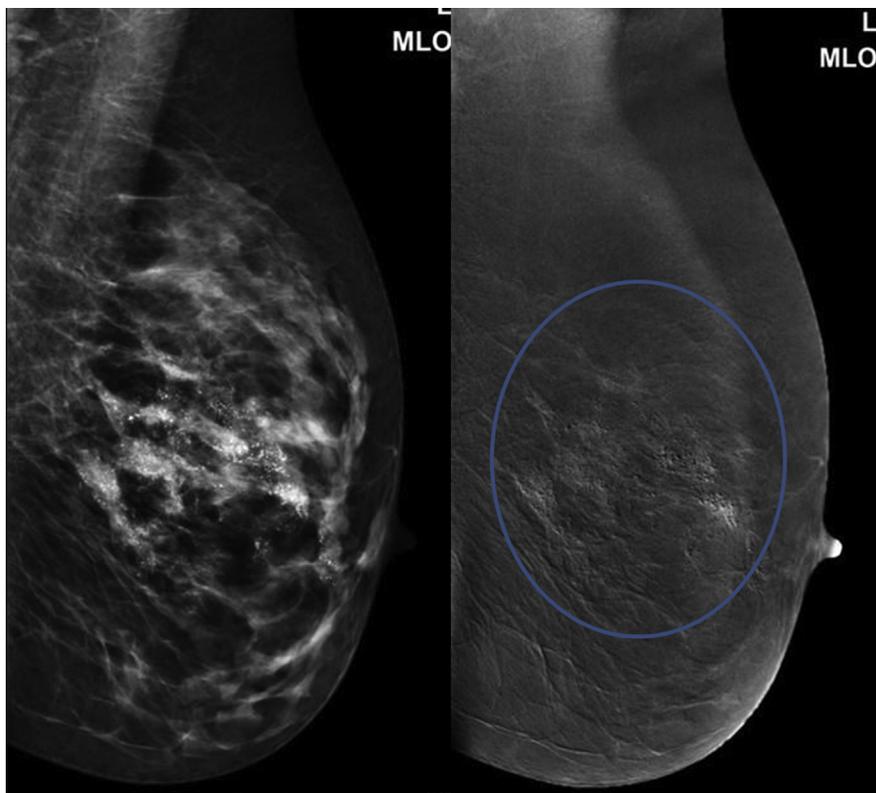


Figure 7 A 38-year-old female patient with left conservative breast surgery with newly developed focal pain and induration at the operative bed. The conventional mammogram MLO view showed suspicious clustered microcalcifications at the operative bed (BI-RADS 4), which showed no contrast medium uptake on the CESM image (circle). This was a false negative case based on the CESM results. Biopsy was undertaken with regard to the suspicious morphology and distribution of the microcalcifications seen on the conventional mammogram.

even in the absence of radiation therapy and up to 18–24 months after radiation therapy.¹⁰

The use of contrast medium reduced the number of the false positives that could be reported when analysing the changes seen at the postoperative breast.¹¹ Belli *et al.* reported high negative predictive values of breast MRI in women who had breast conservative surgery. They concluded that the absence of enhancing foci in post-treatment breasts had 100% reliability for predicting the absence of tumour recurrence.¹²

There may be no need for additional invasive procedures, such as biopsy, in the absence of enhancing foci suspicious of recurrence.^{12,13} In the present study, there were 17 false negative lesions diagnosed at traditional mammography, which was reduced to only three lesions at CESM (Figs 5 and 6a). These three lesions showed inappreciable contrast medium uptake, which may have been due to extensive postoperative scarring/fibrosis, resulting in the misdiagnosis of a normal study at CESM. In these cases biopsy was performed because (1) the patients developed clinical symptoms of a newly developed focal pain and induration at the operative bed and (2) there were suspicious findings on the conventional mammogram (Fig 7).

CESM had a reported sensitivity of 91.2% and positive predictive value of 77.5% in the evaluation of local relapse of cancer in the postoperative breast. The percentage of postoperative-detected malignancy in the current work was

high ($n=34/70$; 48.6%). This could be attributed to the aggressiveness of the previously removed primary breast cancer (tumour receptor expression and biomarkers). In 21 cases diagnosed with local recurrence (61.8%, $n=21/34$), the primary breast cancer subtypes were Her2-enriched (Fig 3) and triple negative/basal-like subtypes (Fig 6b). In addition, one of the inclusion criteria was cases that showed suspicious findings on conventional breast imaging techniques.

The ACR Imaging Network (ACRIN) 6666 first year trial included 2,637 eligible women, of which 1,400 (53% in 2637 women) had a past history of breast cancer. These women were subjected to combined breast cancer screening using ultrasound and mammogram. Forty of these 2,637 participants (1.5%) were diagnosed with cancer, and ultrasound was able to detect an additional 1.1–7.2 cancers per 1,000 high-risk women.¹⁴

Many studies have investigated the role of ultrasound as an adjunct to mammography in the diagnosis of recurrence of malignancy in the postoperative breast.^{15–17} Liu *et al.* performed a retrospective study of 324 patients with breast cancer after mastectomy and reported that postoperative surveillance using ultrasound was able to detect malignant lesions in the breast with high sensitivity (100%) and specificity (99.7%).¹⁸ Ultrasound is, however, an operator-dependent technique with a limited field of view and overlap of findings between benign changes and recurrent malignancy. Imaging the operative bed using ultrasound

alone carries the risk of missed cancer. In the present study, ultrasound was not used in the assessment process as the focus was the performance of CESM for the detection of breast cancer relapse. CESM provided confirmatory data regarding the vague increased/asymmetrical densities commonly seen at mammography of postoperative breasts (Fig 6b); moreover, it demonstrated disease distribution and extent as the cancer may exhibit a focal or multicentric pattern (Fig 3).

The assessment in the study was limited by the absence of an appropriate BI-RADS lexicon for CESM examination. A standardised lexicon of morphology descriptors seen on CESM would provide the optimal analysis and reporting of enhancing lesions detected in the breast.

In conclusion, CESM is a credible technique that could be used in conjunction with the traditional mammogram to screen for cancer in the postoperative breast.

Conflict of interest

The authors declare no conflict of interest.

References

- Chansakul T, Lai KC, Slanetz PJ. The post conservation breast: part 1, expected imaging findings. *AJR Am J Roentgenol* 2012;**198**:321–30.
- Luczyńska E, Paluchowska S, Dyczek S, et al. Contrast-enhanced spectral mammography: comparison with conventional mammography and histopathology in 152 women. *Korean J Radiol* 2014;**6**:689–96.
- Jong RA, Yaffe MJ, Skarpathiotakis M, et al. Contrast-enhanced digital mammography: initial clinical experience. *Radiology* 2003;**228**:842–50.
- Lobbes M, Lalji U, Nelemans P, et al. The quality of tumour size assessment by contrast-enhanced spectral mammography and the benefit of additional breast MRI. *J Cancer* 2015;**6**:144–50.
- Domain C, Thibault F, Muller S, et al. Dual-energy contrast-enhanced digital mammography. *Eur Radiol* 2011;**21**:565–74.
- Blichert TM, Nielsen M, Düring M, et al. Long term results of breast-conserving surgery vs. mastectomy for early stage invasive breast cancer: 20-year follow-up of the Danish randomized DBCG-82TM protocol. *Acta Oncol* 2008;**47**:672–81.
- Drukteinis JS, Gombos EC, Raza S, et al. MR imaging assessment of the breast after breast conservation therapy: distinguishing benign from malignant lesions. *RadioGraphics* 2012;**32**:219–34.
- Kamal RM, Helal MH, Mansour SM, et al. Can we apply the MRI BI-RADS lexicon morphology descriptors on contrast-enhanced spectral mammography? *Br J Radiol* 2016;**89**:20160157.
- Yalcinkaya M, Varer MM, Sarsilmaz A, et al. Contribution of MRI to the mammographic findings in patients with elevated risk of malignancy. *Kocatepe Med J* 2014;**15**:156–63.
- Chae EY, Cha JH, Kim HH, et al. Evaluation of residual disease using breast MRI after excisional biopsy for breast cancer. *AJR Am J Roentgenol* 2013;**200**:1167–73.
- Margolis NE, Morley C, Lotfi P, et al. Update on imaging of the post-surgical breast. *RadioGraphics* 2014;**34**:642–60.
- Belli P, Costantini M, Romani M, et al. Magnetic resonance imaging in breast cancer recurrence. *Breast Cancer Res Treat* 2002;**73**:223–35.
- Quinn EM, Coveney AP, Redmond HP. Use of magnetic resonance imaging in detection of breast cancer recurrence: a systematic review. *Ann Surg Oncol* 2012;**19**:3035–41.
- Berg WA, Blume JD, Cormack JB, et al. Combined screening with ultrasound and mammography vs mammography alone in women at elevated risk of breast cancer. *JAMA* 2008;**299**:2151–63.
- Suh YJ, Kim MJ, Kim EK, et al. Value of ultrasound for postoperative surveillance of Asian patients with history of breast cancer surgery: a single-center study. *Ann Surg Oncol* 2013;**20**:3461–8.
- Kim HJ, Kwak JY, Choi JW, et al. Impact of US surveillance on detection of clinically occult locoregional recurrence after mastectomy for breast cancer. *Ann Surg Oncol* 2010;**17**:2670–6.
- Lee JH, Kim EK, Oh JY, et al. US screening for detection of nonpalpable locoregional recurrence after mastectomy. *Eur J Radiol* 2013;**82**:485–9.
- Liu YQ, Dong JN, Meng QX, et al. Ultrasound for postoperative surveillance after mastectomy in patients with breast cancer: a retrospective study. *Medicine (Baltimore)* 2017;**96**:e9244.