12 Basic Preferences of Breast Imaging

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12.1 Introduction

Breast cancer has been reported to be the most common leading type and cause of cancer deaths among women by global cancer statistics, accounting to 23% of total cancer cases and 14% of cancer deaths. An estimate of 266,120 new cases of invasive breast cancer and 40,920 women deaths from breast cancer in the United States has been found in 2018 by the American Cancer Society (ACS) [1]. Overall, in the United States, the risk of developing breast cancer is 1 in 8 (12%) [2]. Breast cancer is a common disease, and the survival has been greatly improved in recent years. In the United States, the rate of breast cancer death has declined with the widespread use of screening mammography since 1990. However, some advances in systemic treatment options have increased the survival rates of breast cancer patients. Improved survival has been largely linked to screening. Screening mammography that allows diagnosis at an earlier stage of the disease may have an important role in the decrease of mortality rates [3–7].

So many breast cancers are determined by screening abnormal mammograms. Additional mammographic technique (spot-compression magnification views or tomosynthesis views) and ultrasonography are sometimes needed for more accurate diagnosis or indication of biopsy. Furthermore, it is impossible to detect all cancers with the use of mammography. Mammographic occult lesions have been reported to be nearly 15% in such cases [8]. Clinical observation is very important at this point. If there is a suspicious mass lesion clinically, it should be biopsied. The aim of the biopsy is to obtain maximum profit with minimum invasive technique, that is, to prevent unnecessary surgery to benign masses.

Diagnosis of breast cancer are required multidisciplinary approaching amongst clinicians with different specialties. In the same way, multidisciplinary care by breast and reconstructive surgeons, radiation and medical oncologists, radiologists, and pathologists is necessary to treatment planning and patient care after breast cancer is diagnosed [9]. This chapter aims to review the diagnostic workup of women with suspected breast cancer clinically. By the end of this article, the reader will be better equipped to have informed basic preferences of breast imaging for diagnosis of breast cancer.

12.2 Mammography

Diagnostic evaluation of women with suspected breast cancer begins with mammography generally. Breast carcinoma usually presents with

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a palpable breast mass which may be detected on clinical breast examination by a physician or during breast self-examination [10, 11]. In this situation, clinicians need further evaluation in order to find out the etiology of a palpable breast mass lesion. Mammography usually is the first step in diagnostic evaluation of women with suspected breast cancer depending on their age.

Mammographic exam can be classified as screening mammography and diagnostic mammography depending on intended purpose. Both of them are used by clinicians as imaging methods for breast cancer diagnosis. Screening mammography is used to find breast cancers when early stage (small size and no lymphatic involvement, etc.) and also to decrease breast cancer specific mortality in asymptomatic women. Diagnostic mammography is used to evaluate suspicious clinical abnormalities and breast complaints of women distinct from screening mammography.

Breast cancer is determined largely from abnormal mammographic findings [12, 13]. The Breast Cancer Detection Demonstration Project follow-up study showed that mammography detects breast cancer about 90% [13]. Diagnostic mammography detects breast cancer in nearly 35 per 1000 patients, higher compared to screening mammography (5 per 1000 patients) [14, 15]. Because, the patient group of diagnostic mammography has some clinical signs and symptoms in terms of breast cancer. Diagnostic mammography is used to evaluate not only symptomatic younger women but also symptomatic women who have had a negative screening mammogram. For young women (generally under 30–40 years old) who present clinical findings and any symptom, diagnostic mammography is thought to be the initial workup beside ultrasonography (US). A routine mammographic study includes two views of each breast, craniocaudal (CC) and mediolateral oblique (MLO) projections, by compression. Additional spot compression and magnification views may be needed prior to making a final recommendation for management (Fig. 12.1a–d).

12.2.1 Type of Mammographic Technique (the Pros and Cons)

12.2.1.1 Digital Mammography

The imaging used for mammography has evolved from film screen mammography (conventional mammography) to digital mammography (full-field digital mammography) since the 1990s [16]. Digital mammography is favorable for two main groups, women who are perimenopausal and women with heterogeneously dense or extremely dense breasts [14–16]. The use of digital mammography also significantly increased the referral rate as well as cancer detection rate. However, there is a lower positive predictive value of referral and biopsy [2].

12.2.1.2 Digital Breast Tomosynthesis

Digital breast tomosynthesis (DBT) creates a three-dimensional image of the breast and was approved by the Food and Drug Administration in 2011 for breast cancer screening. DBT differs from digital mammography in that the x-ray tube is motorized and able to move through a limited arc to obtain multiple low-dose images. DBT provides thin-section reconstructed images different from conventional mammography. Sectional thin images reduce summation artefact or the lesion-masking effect of overlapping normal tissue and may prevent potential false-positive findings. Studies have shown increased detection rates with DBT in dense breasts as well as a higher average true-positive rate compared with two-dimensional mammography [17, 18]. The sensitivity and specificity are higher, and the overall recall rate has been shown to be lower (Fig. 12.2a–c). Additionally, there was a higher detection of Breast Imaging-Reporting and Data System 5 lesions; however, there was no difference between the detection of benign lesions patient [17, 18].

12.2.1.3 Contrast-Enhanced Digital Mammography

Contrast-enhanced digital mammography (CEDM) or contrast-enhanced spectral mammography is a novel technique based on the same principle as MR imaging by imaging blood flow associated with neovascularity. CEDM uses the platform of digital mammography and is obtained

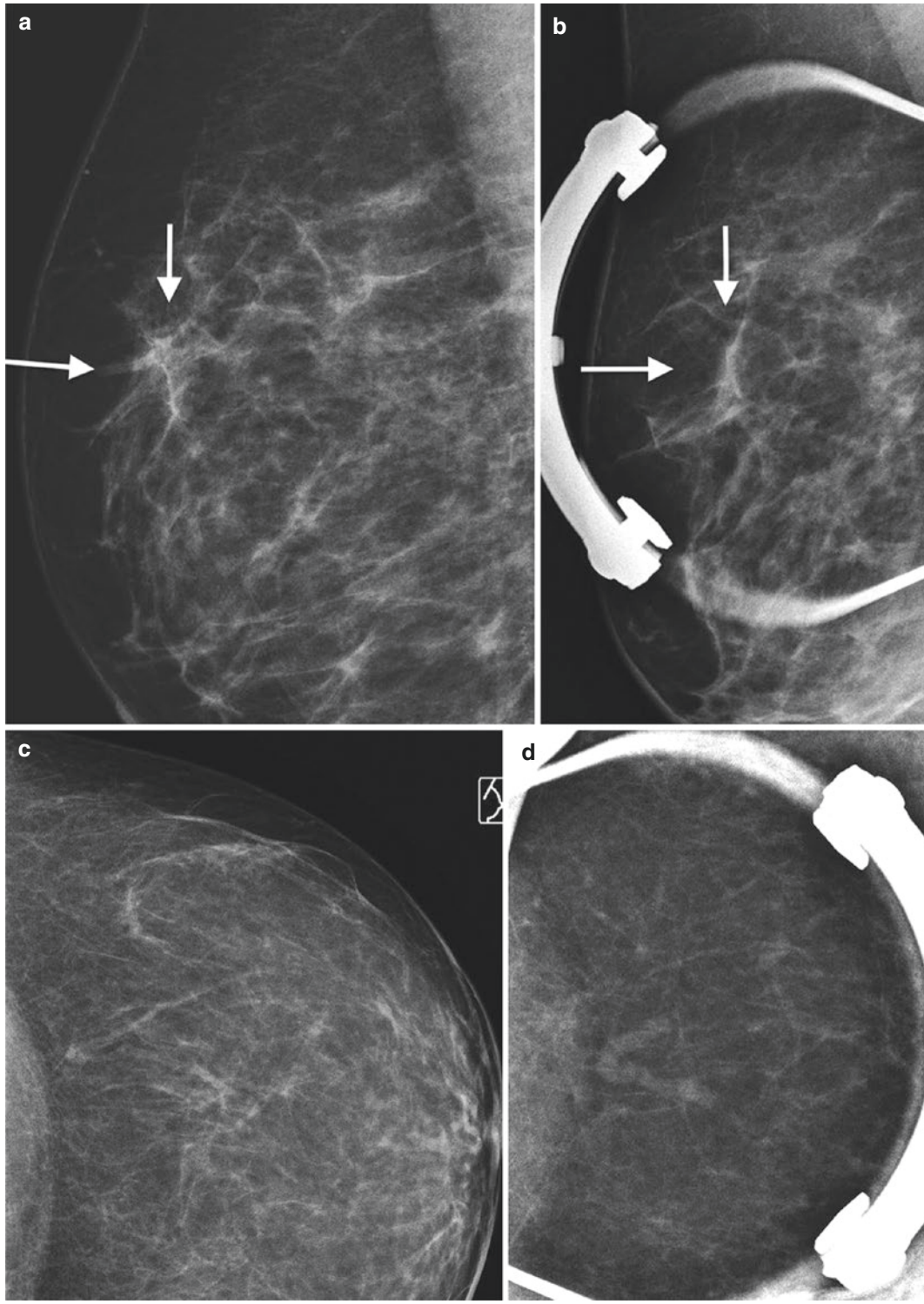

Fig. 12.1 While MLO position (**a**) of mammography demonstrates focal asymmetry (arrows) like spiculated margin mass within right breast upper quadrant, the spot compression MLO view (**b**) demonstrates that suspected spiculated margin area is dissolved and is not seen like mass. Final diagnosis is parenchymal summation. Before taking spot compression mammography, there is suspicious area within CC view (**c**); the spot compression CC view (**d**) showed a normal intramammary vascular structure

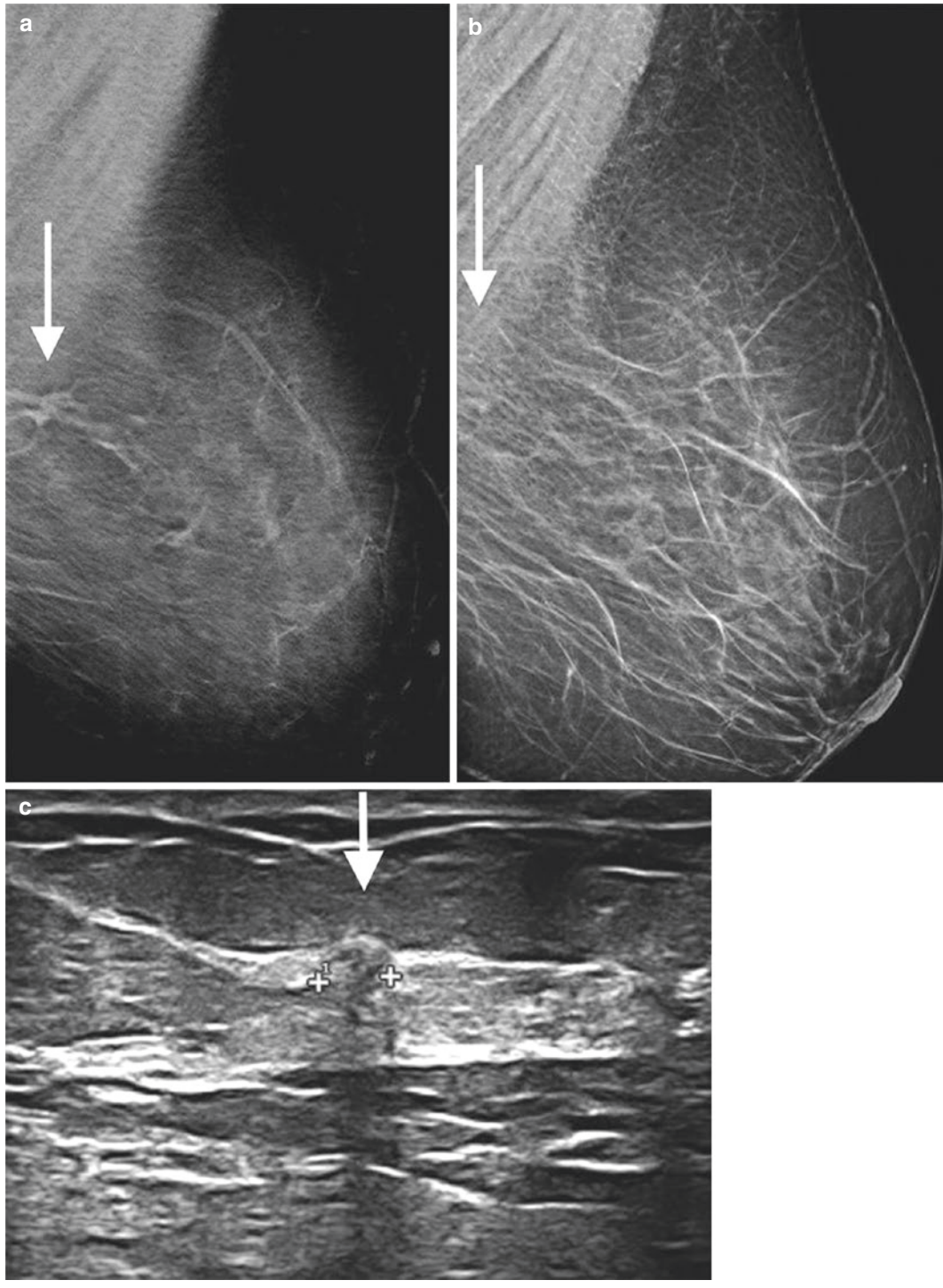

Fig. 12.2 However digital breast tomosynthesis (DBT) demonstrates a mass (arrow) with an irregular shape on left axillary tail (**a**). MLO view shows only faint suspicious appearance within the same localization (**b**). In addition, breast ultrasonography shows round-shaped, smooth margin lesion (arrow) with posterior acoustic shadowing (**c**). Pathology revealed tubular cancer

with mammography before and after intravenous administration of iodinated contrast agent. The radiation dose is approximately 20% more than screening mammogram. CEDM may determine breast cancer through increased contrast uptake of malignancies which show enhanced findings over the normal un-enhancing breast tissue. A group of reviews suggest that CEDM is a potential alternative to MRI in some clinical settings such as recall workup, preoperative staging, and monitoring the effect of neoadjuvant therapy [19].

12.2.2 Suspicious and Malign Features for Breast Cancer on Mammography

Breast cancer has some mammographic features which involve the four main findings shown below:

1. Mass
2. Asymmetry
3. Architectural distortion
4. Microcalcification

The first three of the mammographic features are generated by mass effect of lesion. Typical malign mass lesion has some imaging features which are irregular in shape and have spiculated margins and high density on mammography. The positive predictive value of a mass with irregular shape is 73% with a spiculated margin of 81% (Fig. 12.3a, b) [20, 21]. Approximately one third of noncalcified cancers appear as spiculated masses; 25% as irregularly outlined masses; 25% as less specific round, oval, or lobulated masses; and less than 10% as well-defined round, oval, or lobulated masses [22]. A noncalcified mass with high density is an important indicator in predicting malignancy on mammography. A study has

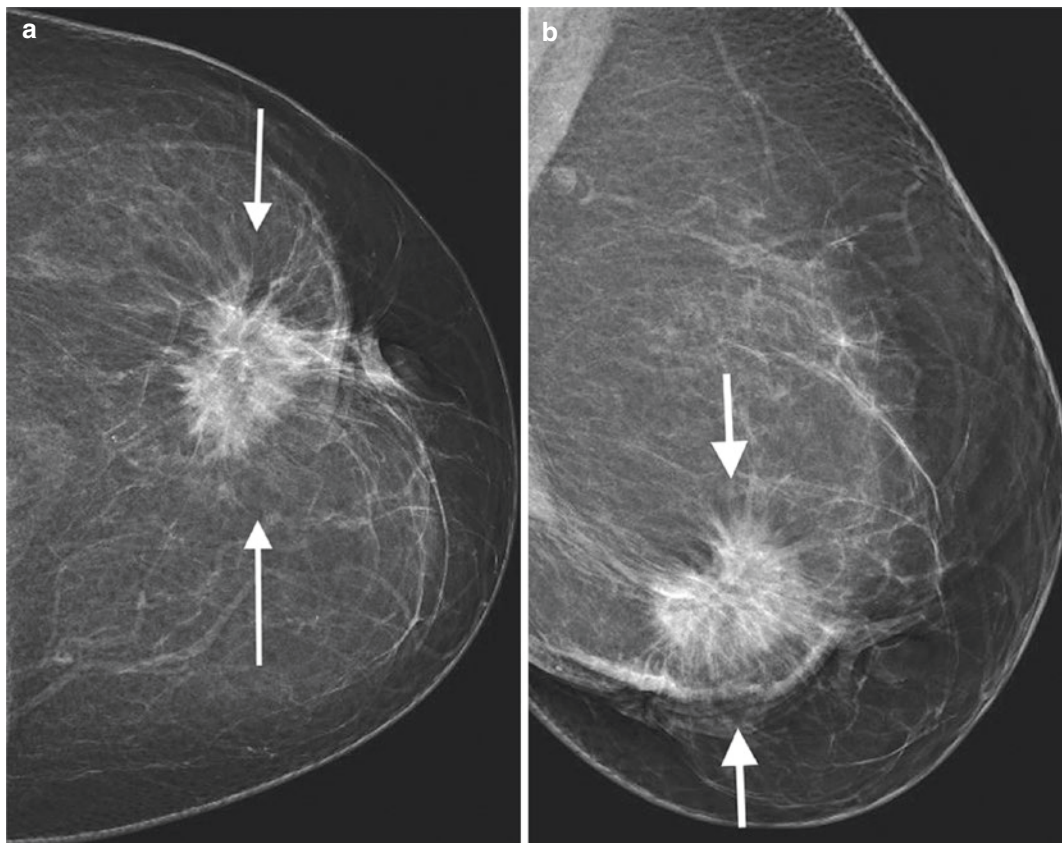

Fig. 12.3 (**a**, **b**) MLO and CC views show a mass (arrow) with irregular-shape and spiculated margin lesion on the left breast. Pathology revealed invasive ductal carcinoma

shown that 70% of masses with high density were malignant and 22% of masses with low density were malignant [21].

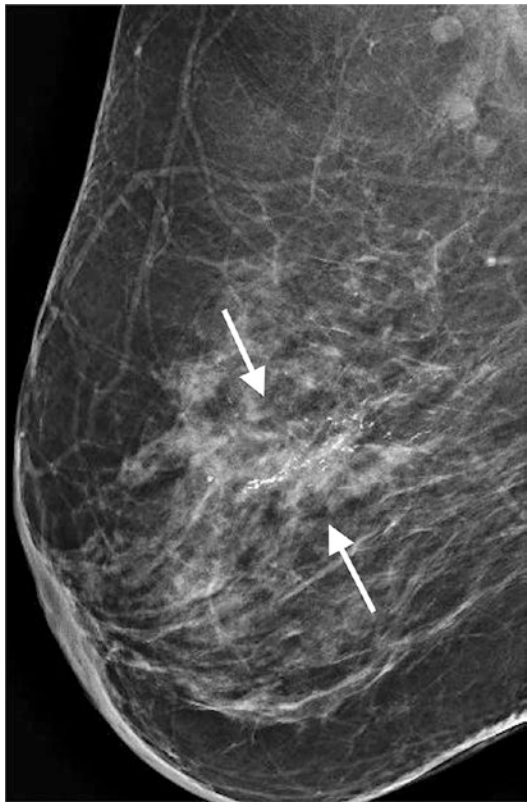

Fig. 12.4 MLO view shows segmental distribution of fine pleomorphic and fine-linear branching calcification (arrows) within the right breast. Pathology revealed invasive carcinoma

In the Breast Imaging-Reporting and Data System (BI-RADS) atlas, calcifications were classified by morphology either as benign or suspicious [23]. Suspicious calcifications (BI-RADS 4B or 4C) are shown as an amorphous, coarse heterogeneous, fine pleomorphic, fine linear, and fine linear branching calcification. The last two, fine linear and fine-linear branching calcifications, have high probability for malignancy and are classified as BI-RADS 4C. Furthermore, probability of malignancy is changed depending on distribution of microcalcification. Distribution type of microcalcification such as grouped, segmental, and linear distribution is a significant indicator in predicting malignancy on mammography (Fig. 12.4). Clustered microcalcifications are described calcium particles of various sizes (between 0.1 and 1 mm) and shapes, which are more than 4–5 per cubic centimeter, seen in approximately 60% of cancers detected mammographically (Fig. 12.5a, b).

12.2.2.1 Breast Imaging-Reporting and Data System

At the end of the imaging workup, the radiologist communicates to the referring physician by using the tool Breast Imaging-Reporting and Data System (BI-RADS) clearly and consistently, with a final assessment and specific management recommendations. BI-RADS has been developed by the American College of Radiology (ACR); the fifth edition has been used since 2013 [23]. The BI-RADS atlas provides standardized breast

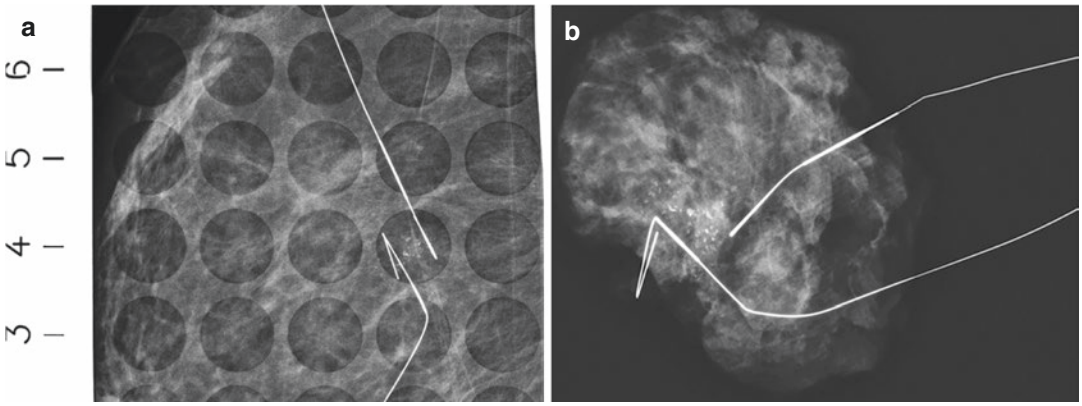

Fig. 12.5 Preoperative MLO shows pleomorphic clustered calcification (**a**); postoperative specimen radiography demonstrated that all of them was excisioned (**b**). Pathology revealed ductal carcinoma in situ with high grade

imaging terminology, report organization, assessment structure, and a classification system for mammography, ultrasound, and magnetic resonance imaging (MRI) of the breast. BI-RADS assessment categories are shown in Table 12.1. The BI-RADS assessment Category 0 (Incomplete) is used when additional imaging workup is required to make a final assessment, primarily from screening examinations and rarely from a diagnostic study. BI-RADS Category 1 (Negative) and BI-RADS Category 2 (Benign finding) should only be used when the mammography report describes benign findings. BI-RADS Category 3 (Probably benign finding) is used if a patient has less than 2% likelihood of malignancy. This group of patient is followed up in short intervals (6 months) or undergoes continued surveillance mammography. When BI-RADS assessment categories 4 and 5 are reported, a biopsy should be performed in the absence of clinical contraindication to tissue diagnosis.

12.2.2.2 Breast Density-Related Issues and Preferences

Increased breast density is associated with an increased risk of breast cancer and also decreased mammographic sensitivity, thereby increasing the risk of interval cancers. Studies show that mammographic sensitivity is low in women with extremely dense breasts (30–64%) in comparison with fatty breast (76–98%) [24, 25]. Some adjunct screening modalities like US, DBT, and MRI have been used result from the limitation of mammography in selected cases [26]. Breast density is notified into BI-RADS reporting and also is taken into account while reading of mammographic report to pave way for good management option. The 2013 BI-RADS density terminology is used to classify levels of breast density which involve four categories ("a" to "d") as shown below [23]:

(a) Breast tissue is almost entirely fatty 10%.
(b) Breast tissue with scattered areas of fibroglandular density 40%.
(c) Breast tissue is heterogeneously dense, which may obscure small masses 40%.
(d) Breast tissue is extremely dense, which lowers the sensitivity of mammography 10%.

12.3 Breast Ultrasound

Breast ultrasonography is widely used as an adjunct modality to mammography for the detection and also staging of breast cancer. Ultrasound is frequently performed to confirm correlation of imag-

Table 12.1 BI-RADS assessment categories

	Assessment	Management	Likelihood of cancer
Category 0	Incomplete	Recall for additional imaging and/or comparison with prior examination(s)	N/A
Category 1	Negative	Routine mammography screening	Essentially 0% likelihood of malignancy
Category 2	Benign	Routine mammography screening	Essentially 0% likelihood of malignancy
Category 3	Probably benign	Short-interval (6-month) follow-up or continued surveillance mammography	>0 but ≤2% likelihood of malignancy
Category 4	Suspicious	Tissue diagnosis	>2 but <95% likelihood of malignancy
Category 4A	Low suspicion for malignancy		>2 to ≤10% likelihood of malignancy
Category 4B	Moderate suspicion for malignancy		>10 to ≤50% likelihood of malignancy
Category 4C	High suspicion for malignancy		>50 to <95% likelihood of malignancy
Category 5	Highly suggestive of malignancy		≥95% likelihood of malignancy
Category 6	Known biopsy-proven malignancy	Surgical excision when clinically appropriate	N/A

ing and clinical findings, as well as lesion characterization. Since younger women have lower mammographic sensitivity depending on dense breast tissue and the theoretically increased radiation risk for mammography, US is the first-line option for women below 30 years age [27–29].

Breast US has some special roles in evaluating breast tumors that are palpable or detected mammographically. And also, US provides detecting of axillary lymphadenopathy and guiding of some breast interventional procedures. Purposes of breast US in diagnosis of breast cancer are summarized briefly below.

12.3.1 To Further Evaluate Focal Palpable Findings Which Are Detected on Clinical Breast Examination

- If ultrasound demonstrates a simple cyst, clinical follow-up is sufficient without imaging surveillance.
- If ultrasound reveals solid masses with benign imaging features (oval shape, circumscribed, etc.), short-term (6 months) follow-up and then periodic surveillance are a reasonable alternative to biopsy particularly for young women with probable fibroadenoma. One study showed a less than 2% likelihood of malignancy for solid masses with benign features [30].
- Even if the ultrasound finding is negative, mammography is still recommended as a prebiopsy assessment in patients in whom cancer is strongly suspected clinically [31].
- Even if the results of ultrasound and mammography are negative, tissue sampling is necessary in women aged 40 years and whose physical examination is highly suspicious.

12.3.2 To Further Evaluate Suspicious Findings Which Are Detected on Mammography

Mammography always doesn't distinguish between benign and malignant lesion. US is used as the next step especially in women 40 years old as a problem-solving modality. US may be able to detect the lesion which is mammographically occult or may further characterize it (Fig. 12.6a, b). To decide on which management is favorable, US and mammography findings are evaluated simultaneously.

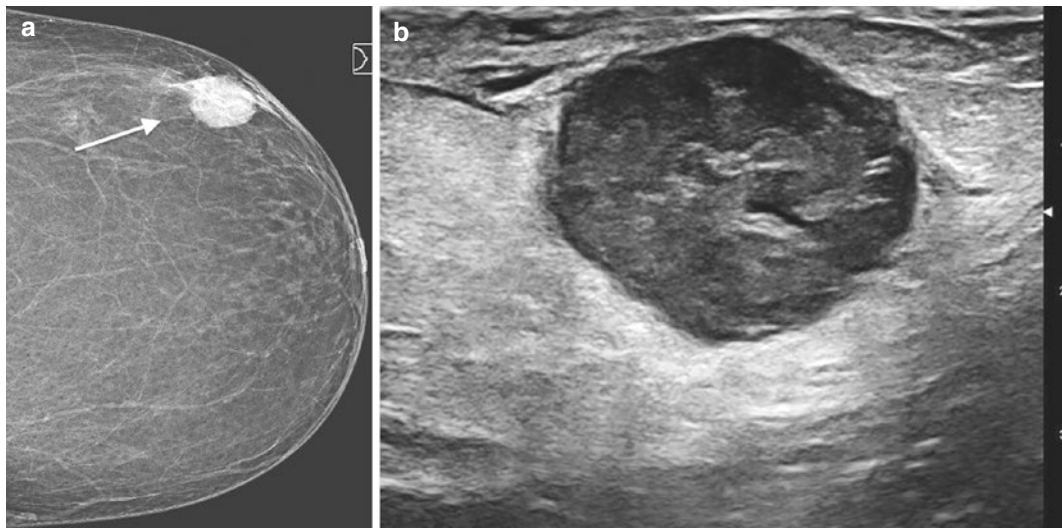

Fig. 12.6 CC position mammogram view shows oval-shape, high-density lesion with some suspicious margin lobulation (arrow) (**a**). US demonstrated that there is a solid lesion with margin lobulations precisely and also lesion with a non-parallel orientation to the breast skin (**b**). Pathology revealed invasive carcinoma

12.3.3 To Evaluate Axillary Region in Order to Reveal Lymph Node Involvement Status

Preoperative axillary US provides additional information about axillary lymph node involvement status. And also, US with fine needle aspiration or core biopsy demonstrates whether lymph nodes are involved. This information steers the management of breast cancer.

12.3.4 As Guide in the Performance of Breast Biopsy and to Place Clip into a Lesion for Localization Prior to Neoadjuvant Chemotherapy

See Chap. 13.

12.4 Breast Magnetic Resonance Imaging

Magnetic resonance imaging of the breast is a useful and a problem-solving tool for the detection and characterization of breast disease, assessment of local disease extent, evaluation of treatment response, and guidance for biopsy and localization. MR imaging is the most sensitive imaging method for breast cancer detection. The sensitivity of MRI ranges from 71% to 100% compared to 35% to 50% for mammography in high-risk women with dense breasts. It is in large part due to the ability of MRI to image neovascularity [32–34]. The specificity of MR imaging has been demonstrated to be lower than that of mammography in many studies, resulting in more recalls and biopsies [32–34]. With the improvement of specificity, to some extent, MRI findings should be correlated with clinical history, physical examination findings, and results of mammography and any other prior breast imaging such as US. Roles of breast MRI in diagnosis and screening of breast cancer are summarized below.

12.4.1 Preoperative Breast MRI

12.4.1.1 Assessment of Ipsilateral Breast (Extent of Disease Within Ipsilateral Breast)

After diagnosis of breast cancer, some situations are taken into consideration which are extent of disease within ipsilateral breast and whether the presence disease of contralateral breast before deciding of management. Breast MRI may be used in patients with invasive carcinoma and DCIS as a preoperative imaging modality in order to evaluate the presence of multifocality and multicentricity and also tumor extension. Studies show that MRI can detect occult disease in the ipsilateral breast (containing the index malignancy) in approximately 15% of patients, with ranges reported from 12% to 27% [35, 36]. Breast MRI is a useful device to evaluate tumor invasion depth to the chest wall. Preoperative MRI assessment of breast carcinoma may be useful to evaluate the relationship of the tumor to the chest wall such as the pectoralis major, its muscular fascia, and others [37].

12.4.1.2 Assessment of Contralateral Breast

Bilateral breast MRI for patients with a newly diagnosed breast malignancy can detect synchronous malignancy in the contralateral breast in at least 3–5% of patients [35, 36]. The incidence of metachronous contralateral cancer may be reduced by using of breast MRI.

12.4.1.3 Assessment of Response of Neoadjuvant Chemotherapy

Breast MRI may be useful before, during, and/or after neoadjuvant chemotherapy for evaluating treatment response. Evaluation of response to neoadjuvant chemotherapy with breast MRI can predict subsequent adjuvant chemotherapy response (Fig. 12.7a, b). In order to find tumor location during breast surgery in the event of complete response, MRI-compatible markers should be placed within the tumor prior to neoadjuvant chemotherapy [37, 38].

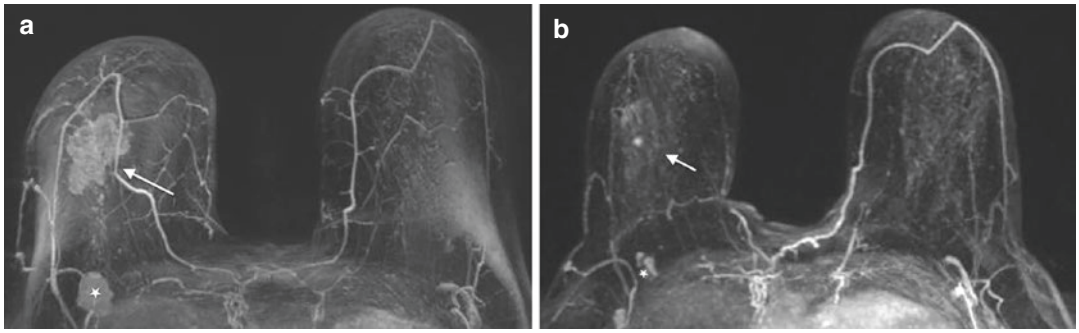

Fig. 12.7 While breast magnetic resonance imaging shows a large mass lesion (arrow) with axillary lymphadenopathy (asterix) on the right breast during timely diagnosis (**a**), after neoadjuvant chemotherapy, size of lesion (arrow) and axillary lymphadenopathy (asterix) decreased prominently (**b**)

12.4.1.4 Guiding of MRI Interventional Procedures

When a breast cancer lesion isn't seen with mammography and US, MRI can be a useful tool with guidance of vacuum-assisted biopsy and placement of marker wire.

12.4.1.5 Further Evaluation and Characterization of Inconclusive Breast Lesion

In daily radiology practice, US and mammography and physical examination findings are not enough to reach a satisfactory final diagnosis for some inconclusive breast lesions like nipple discharge with unknown origin and some mammographic suspicious appearance (architectural distortion, one-view suspicious appearance, etc.). In these cases, breast MRI can be used as a problem-solving modality [39, 40].

12.4.2 Postoperative Breast MRI

12.4.2.1 Postoperative Evaluation of Patients with Recurrent Breast Cancer

In the postoperative setting, if clinical and radiologic findings are inconclusive to evaluate suspected recurrence, breast MRI may be used in women with previous breast cancer history [41].

12.4.2.2 Postoperative Evaluation of Tissue Reconstruction and Breast Augmentation

Breast MRI is used in differentiating between recurrence and fat necrosis in patients with history of breast cancer reconstructed by autologous fat grafting. Non-contrast breast MR is sufficient almost all the time when evaluating the integrity of silicone implants. Contrast-enhanced breast MRI is needed to evaluate patients who have undergone implant reconstruction following lumpectomy or mastectomy for breast cancer.

12.4.3 Other Roles of Breast MRI

12.4.3.1 Metastatic Cancer with Unknown Primary Origin

Breast MRI is taken into consideration to evaluate patients presenting with axillary or distant metastatic disease. This group of patients doesn't have any sign of breast cancer within mammography or physical exam for primary breast carcinoma. Some studies showed that occult primary breast tumor can be found in nearly half of women presenting with metastatic axillary lymph adenopathy with breast MRI [42].

12.4.3.2 Screening of High-Risk and Intermediate-Risk Patients for Breast Cancer

Since 2007, the American Cancer Society has recommended annual screening mammography and supplemental screening MR imaging for the following women [43]:

- Estimated lifetime risk of 20% for breast cancer
- BRCA mutation carriers
- First-degree relatives of BRCA mutation carriers who remain untested
- Mediastinal irradiation between the ages of 10 and 30
- Certain genetic syndromes (Li-Fraumeni, Cowden, Bannayan-Riley-Ruvalcaba)

The NCCN guidelines advice that screening of high-risk patients is to begin 10 years prior to the youngest family member (the first-degree relative) with breast cancer with MR imaging at age 25 and with mammography at age 30 [43].

12.5 Nipple Discharge

Nipple discharge is the third most common complaint (nearly 7% of all breast complaints) after breast pain and breast masses [44]. Nipple discharge can result from pathologic or benign or physiologic causes [45].

Selection of imaging method in patients with nipple discharge is summarized below according to ACR Appropriateness Criteria [44]:

- Imaging is not necessary for evaluation of physiologic nipple discharge.
- For women 40 years of age or older, mammography or DBT should be the initial examination. US is usually added as a complementary examination. Mammography should be repeated if prior mammography was performed >6 months ago. MRI or ductography may be useful when the initial imaging evaluation is negative.
- For women 30–39 years of age, US can be used as an initial examination in place of mammography. Further evaluation can be done with mammography or DBT depending on US findings.
- For women 30 years of age or younger, US should be the initial examination. Mammography or DBT may be complementary depending on US findings or if the patient has a genetic mutation predisposing to breast cancer.

12.6 Age-Related Preferences and Sceneries for Palpable Breast Masses

12.6.1 For Women 40 Years of Age or Older

Diagnostic mammography is indicated as the initial examination in the evaluation of a palpable breast finding for women aged 40 years.

12.6.1.1 Scenery 1: Mass with Probably Benign Features (BI-RADS 3) on Mammography

Depending on the outcome of the mammographic exam, if the mass lesion has probably benign features (BI-RADS category 3), further evaluation is needed by US. After evaluation of US, mass is categorized using BI-RADS classification. Finally, if a lesion is categorized as BI-RADS category 3, follow-up and then periodic surveillance may be the appropriate management in lieu of biopsy. If the mass is new on imaging, then biopsy is indicated [18].

12.6.1.2 Scenery 2: Suspicious or Malignant Findings (BI-RADS 4 or 5) on Mammography

If the radiologist notifies suspicious (BI-RADS category 4) or malignant findings (BI-RADS category 5) after review of mammographic exam, patient has to be further evaluated by US. Biopsy planning and performing can be done with US. If it is necessary, MRI can be selected to evaluate extent of disease before deciding on the management plan [18].

12.6.1.3 Scenery 3: Less Concerning Finding on Clinical Examination

If the patient has less concerning evidence according to clinical exam, after negative or benign imaging findings, further evaluation is not required. US can be opted to confirm correlation of imaging and clinical findings as an adjunct modality.

12.6.2 For Women 30–39 Years of Age

The term "young" is usually described in ages less than 30 years old [11]. In young women, many lesions can be not visualized on mammography due to increased breast density [31]. Since the sensitivity of ultrasound is higher than mammography, ultrasound is selected as the initial imaging modality in women aged <40 years.

12.6.2.1 Scenery 1: Solid Mass with Probable Benign Features

If a palpable breast mass is certainly classified as benign on US (simple cyst, duct ectasia, lipoma, etc.), short clinical follow-up is preferred in lieu of imaging follow-up or tissue sampling.

12.6.2.2 Scenery 2: Suspicious or Malignant Findings (BI-RADS 4 or 5)

If ultrasound demonstrates a suspicious finding in a younger woman, bilateral mammography is recommended to evaluate for additional ipsilateral and contralateral lesions. Mammogram with radiopaque marker over palpable finding and spot compression views or DBT with or without spot compression is preferred to further characterize the lesion, to assess for extent of disease, and to evaluate contralateral breast [18].

12.6.2.3 Scenery 3: If Less Concerning Finding on Clinical Examination

If the patient has less concerning evidence according to clinical exam, firstly, US exam is preferred to find out the cause of palpable findings. When any typical benign lymph node or cyst is detected, the patient is classified BI-RADS 2, and further evaluation isn't necessary. When there is no correlation between imaging and clinical findings, further evaluation with mammography and DBT is needed.

12.6.3 For Women 30–39 Years of Age

A large series study shows that ultrasound has higher sensitivity than mammography (95.7% vs 60.9%, respectively), in women with complaints of focal breast symptoms 30–39 years of age [46]. So, ultrasound or mammography is opted to evaluate focal palpable clinical findings in this women age group.

12.6.3.1 Scenery 1: Management of Palpable Findings in Women

First option of imaging can be mammography or US according to clinical findings. If the patient has less concerning evidence according to clinical exam, after negative or benign imaging findings, further evaluation is not required.

12.7 Preoperative and Postoperative Preferences

12.7.1 Assessment of Preoperative and Perioperative Breast Cancer Patient (In Terms of Extent of Disease)

Accurate delineation of tumor size and extent of disease are too significant to plan the appropriate surgery especially breast-conserving surgery (BCS) depending on patient's age and clinical findings. Preoperative extent of disease is usually evaluated with mammography and/or US and sometimes MRI in selected cases only. Specimen radiography can be used to determine intraoperative resection margin during BCS. It has been

reported in literature that the diagnostic accuracy, sensitivity, and specificity are 60–84, 55–60, and 60–92%, respectively [47].

12.7.2 Assessment of Postoperative Breast Cancer Patient (In Terms of Residue and Recurrence of Disease)

After BCS, patients are closely monitored at variable intervals up to 5 years with mammography and physical examination [48]. Annual mammograms are appropriate for the surveillance of breast cancer patients who have had BCS and radiation therapy. There is no clear benefit in shorter-interval imaging. At the end of radiation therapy, patients should wait 6–12 months to begin their annual mammogram surveillance. Any suspicious findings on physical examination or surveillance imaging might warrant a shorter interval between mammograms [48].

In recent years, usage of breast MRI has increased in breast cancer diagnosis in the preoperative and postoperative setting [49]. Currently, the use of breast MRI is helpful when mammography and ultrasound are equivocal especially differentiation recurrence and postoperative changes (scar tissue, fat necrosis, etc.). Postoperative scar tissue usually is not enhanced. One study showed that the absence of enhancement in breast MRI was associated with an 88% negative predictive value for cancer [50].

12.8 Conclusion

Although breast cancer is a common disease, and the survival has been greatly improved in recent years, this success has been achieved by multidisciplinary care. In the future, breast imaging and its diagnostic roles will further increase in daily medical practice. As mentioned in the above chapters, clinical team is worked coordinately, and attention should be paid to two messages as mentioned below:

- Any highly suspicious breast mass detected by imaging should be biopsied, irrespective of clinical findings.
- Any highly suspicious breast mass detected by clinically should be biopsied, irrespective of imaging findings.

Tips and Tricks (for Sect. 12.6)

- Diagnostic mammography or DBT and US are the first-line modalities for evaluating a clinically detected palpable breast mass. MR may be a useful selected case as a problem-solving modality.
- With a clinically detected palpable breast mass, imaging modality is selected depending on women's age:
  - Diagnostic mammography or DBT is the first option in women aged 40 years or older.
  - Breast US is the first option in women younger than 30 years of age.
  - Either US or diagnostic mammography or DBT is the first option for women aged 30–39 years.

References

1. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2018. CA Cancer J Clin. 2018;68(1):7–30. https://doi.org/10.3322/caac.21442.
2. Witten M, Parker CC. Screening mammography: recommendations and controversies. Surg Clin North Am. 2018;98(4):667–75. https://doi.org/10.1016/j.suc.2018.03.003.
3. Hellquist BN, Duffy SW, Abdsaleh S, Björneld L, Bordás P, Tabár L, et al. Effectiveness of population-based service screening with mammography for women ages 40 to 49 years: evaluation of the Swedish mammography screening in young women (SCRY) cohort. Cancer. 2011;117(4):714–22. https://doi.org/10.1002/cncr.25650.
4. Saadatmand S, Bretveld R, Siesling S, Tilanus-Linthorst MM. Influence of tumour stage at breast cancer detection on survival in modern times: population based study in 173,797 patients. BMJ. 2015;351:h4901. https://doi.org/10.1136/bmj.h4901.
5. Munoz D, Near AM, van Ravesteyn NT, Lee SJ, Schechter CB, Alagoz O, et al. Effects of screen-

ing and systemic adjuvant therapy on ER-specific US breast cancer mortality. J Natl Cancer Inst. 2014;106(11):pii: dju289. https://doi.org/10.1093/jnci/dju289.
6. de Gelder R, Heijnsdijk EA, Fracheboud J, Draisma G, de Koning HJ. The effects of population-based mammography screening starting between age 40 and 50 in the presence of adjuvant systemic therapy. Int J Cancer. 2015;137(1):165–72. https://doi.org/10.1002/ijc.29364.
7. Berry DA, Cronin KA, Plevritis SK, Fryback DG, Clarke L, Zelen M, et al. Effect of screening and adjuvant therapy on mortality from breast cancer. N Engl J Med. 2005;353(17):1784–92.
8. Barlow WE, Lehman CD, Zheng Y, Ballard-Barbash R, Yankaskas BC, Cutter GR, et al. Performance of diagnostic mammography for women with signs or symptoms of breast cancer. J Natl Cancer Inst. 2002;94(15):1151–9.
9. Chang JH, Vines E, Bertsch H, Fraker DL, Czerniecki BJ, Rosato EF, et al. The impact of a multidisciplinary breast cancer center on recommendations for patient management: the University of Pennsylvania experience. Cancer. 2001;91(7):1231–7.
10. Harvey JA, Mahoney MC, Newell MS, Bailey L, Barke LD, D'Orsi C, et al. ACR appropriateness criteria palpable breast masses. J Am Coll Radiol. 2016;13(11S):e31–42. https://doi.org/10.1016/j.jacr.2016.09.022.
11. American Cancer Society. Cancer facts & figures 2012. Atlanta: American Cancer Society; 2012.
12. Smart CR, Hartmann WH, Beahrs OH, Garfinkel L. Insights into breast cancer screening of younger women. Evidence from the 14-year follow-up of the breast cancer detection demonstration project. Cancer. 1993;72:1449.
13. Stomper PC, Winston PS, Proulx GM, et al. Mammographic detection and staging of ductal carcinoma in situ: mammographic-pathologic correlation. Semin Breast Dis. 2000;3:1.
14. Sprague BL, Arao RF, Miglioretti DL, Henderson LM, Buist DS, Onega T, et al. National performance benchmarks for modern diagnostic digital mammography: update from the breast cancer surveillance consortium. Radiology. 2017;283(1):59–69. https://doi.org/10.1148/radiol.2017161519.
15. Lehman CD, Arao RF, Sprague BL, Lee JM, Buist DS, Kerlikowske K, et al. National performance benchmarks for modern screening digital mammography: update from the breast cancer surveillance consortium. Radiology. 2017;283(1):49–58. https://doi.org/10.1148/radiol.2016161174.
16. Garg AS, Rapelyea JA, Rechtman LR, Torrente J, Bittner RB, Coffey CM, et al. Full-field digital mammographic interpretation with prior analog versus prior digitized analog mammography: time for interpretation. Am J Roentgenol. 2011;196(6):1436–8. https://doi.org/10.2214/AJR.10.5430.
17. Brandt KR, Craig DA, Hoskins TL, Henrichsen TL, Bendel EC, Brandt SR, et al. Can digital breast tomosynthesis replace conventional diagnostic mammography views for screening recalls without calcifications? A comparison study in a simulated clinical setting. Am J Roentgenol. 2013;200(2):291–8. https://doi.org/10.2214/AJR.12.8881.
18. Moy L, Heller SL, Bailey L, D'Orsi C, DiFlorio RM, Green ED, et al. ACR Appropriateness Criteria® palpable breast masses. J Am Coll Radiol. 2017;14(5S):S203–24. https://doi.org/10.1016/j.jacr.2017.02.033.
19. Zanardo M, Cozzi A, Trimboli RM, Labaj O, Monti CB, Schiaffino S, et al. Technique, protocols and adverse reactions for contrast-enhanced spectral mammography (CESM): a systematic review. Insights Imaging. 2019;10(1):76. https://doi.org/10.1186/s13244-019-0756-0.
20. Liberman L, Abramson AF, Squires FB, Glassman JR, Morris EA, Dershaw DD. The breast imaging reporting and data system: positive predictive value of mammographic features and final assessment categories. Am J Roentgenol. 1998;171(1):35–40.
21. Woods RW, Sisney GS, Salkowski LR, Shinki K, Lin Y, Burnside ES. The mammographic density of a mass is a significant predictor of breast cancer. Radiology. 2011;258(2):417–25. https://doi.org/10.1148/radiol.10100328.
22. Stomper PC. Breast imaging. In: Hayes DF, editor. Atlas of breast cancer. Philadelphia: Mosby; 2000. p. 54.
23. D'Orsi CJ, Sickles EA, Mendelson EB, Morris EA, et al. ACR BI-RADS® atlas, breast imaging reporting and data system. American College of Radiology: Reston, VA; 2013.
24. van der Waal D, Ripping TM, Verbeek AL, Broeders MJ. Breast cancer screening effect across breast density strata: a case-control study. Int J Cancer. 2017;140(1):41–9. https://doi.org/10.1002/ijc.30430.
25. Mandelson MT, Oestreicher N, Porter PL, White D, Finder CA, Taplin SH, et al. Breast density as a predictor of mammographic detection: comparison of interval- and screen-detected cancers. J Natl Cancer Inst. 2000;92(13):1081–7.
26. Niell BL, Freer PE, Weinfurtner RJ, Arleo EK, Drukteinis JS. Screening for breast Cancer. Radiol Clin N Am. 2017;55(6):1145–62. https://doi.org/10.1016/j.rcl.2017.06.004.
27. Feig SA. Breast masses. Mammographic and sonographic evaluation. Radiol Clin N Am. 1992;30:67–92.
28. Checka CM, Chun JE, Schnabel FR, Lee J, Toth H. The relationship of mammographic density and age: implications for breast cancer screening. Am J Roentgenol. 2012;198:W292–5.
29. https://www.nccn.org/professionals/physician_gls/pdf/breast-screening.pdf. Accessed 28 Aug 2019.
30. Harvey JA, Nicholson BT, Lorusso AP, Cohen MA, Bovbjerg VE. Short-term follow-up of palpable breast lesions with benign imaging features: evaluation of 375 lesions in 320 women. Am J Roentgenol. 2009;193(6):1723–30. https://doi.org/10.2214/AJR.09.2811.

31. Ciatto S, Bravetti P, Bonardi R, Rosselli del Turco M. The role of mammography in women under 30. Radiol Med. 1990;80:676–8.
32. Lehman CD. Role of MRI in screening women at high risk for breast cancer. J Magn Reson Imaging. 2006;24(5):964–70.
33. Liu M, Guo X, Wang S, Jin M, Wang Y, Li J, Liu J. BOLD-MRI of breast invasive ductal carcinoma: correlation of R2* value and the expression of HIF-1α. Eur Radiol. 2013;23(12):3221–7. https://doi.org/10.1007/s00330-013-2937-4.
34. Sardanelli F, Podo F. Breast MR imaging in women at high-risk of breast cancer. Is something changing in early breast cancer detection? Eur Radiol. 2007;17(4):873–87.
35. Hollingsworth AB, Stough RG, O'Dell CA, Brekke CE. Breast magnetic resonance imaging for preoperative locoregional staging. Am J Surg. 2008;196(3):389–97.
36. Barco I, Chabrera C, García-Fernández A, Fraile M, Vidal M, González S, et al. Magnetic resonance imaging in the preoperative setting for breast cancer patients with undetected additional disease. Eur J Radiol. 2016;85(10):1786–93. https://doi.org/10.1016/j.ejrad.2016.07.020.
37. Kazama T, Nakamura S, Doi O, Suzuki K, Hirose M, Ito H. Prospective evaluation of pectoralis muscle invasion of breast cancer by MR imaging. Breast Cancer. 2005;12(4):312–6.
38. Marinovich ML, Houssami N, Macaskill P, Sardanelli F, Irwig L, Mamounas EP, et al. Meta-analysis of magnetic resonance imaging in detecting residual breast cancer after neoadjuvant therapy. J Natl Cancer Inst. 2013;105(5):321–33. https://doi.org/10.1093/jnci/djs528.
39. Giess CS, Chikarmane SA, Sippo DA, Birdwell RL. Clinical utility of breast MRI in the diagnosis of malignancy after inconclusive or equivocal mammographic diagnostic evaluation. Am J Roentgenol. 2017;208:1378–85.
40. Berger N, Luparia A, Di Leo G, Carbonaro LA, Trimboli RM, Ambrogi F, et al. Diagnostic performance of MRI versus Galactography in women with pathologic nipple discharge: a systematic review and meta-analysis. Am J Roentgenol. 2017;209(2):465–71. https://doi.org/10.2214/AJR.16.16682.
41. Bennani-Baiti B, Bennani-Baiti N, Baltzer PA. Diagnostic performance of breast magnetic resonance imaging in non-calcified equivocal breast findings: results from a systematic review and meta-analysis. PLoS One. 2016;11(8):e0160346.
42. Buchanan CL, Morris EA, Dorn PL, Borgen PI, Van Zee KJ. Utility of breast magnetic resonance imaging in patients with occult primary breast cancer. Ann Surg Oncol. 2005;12(12):1045–53.
43. Saslow D, Boetes C, Burke W, Harms S, Leach MO, Lehman CD, et al. American Cancer Society guidelines for breast screening with MRI as an adjunct to mammography. CA Cancer J Clin. 2007;57(2):75–89.
44. Lee SJ, Trikha S, Moy L, Baron P, DiFlorio RM, Green ED, et al. ACR Appropriateness Criteria® evaluation of nipple discharge. J Am Coll Radiol. 2017;14(5S):S138–53. https://doi.org/10.1016/j.jacr.2017.01.030.
45. Mansel RE, Webster D, Sweetland H. Hughes, Mansel & Webster' s benign disorders and diseases of the breast. 3rd ed. Philadelphia, PA: Saunders; 2009.
46. Lehman CD, Lee CI, Loving VA, Portillo MS, Peacock S, Demartini WB. Accuracy and value of breast ultrasound for primary imaging evaluation of symptomatic women 30-39 years of age. Am J Roentgenol. 2012;199(5):1169–77. https://doi.org/10.2214/AJR.12.8842.
47. Urano M, Shiraki N, Kawai T, Goto T, Endo Y, Yoshimoto N, et al. Digital mammography versus digital breast tomosynthesis for detection of breast cancer in the intraoperative specimen during breast-conserving surgery. Breast Cancer. 2016;23(5):706–11. https://doi.org/10.1007/s12282-015-0628-5.
48. https://www.nccn.org/professionals/physician_gls/pdf/breast.pdf. Accessed 28 Aug 2019.
49. https://www.acr.org/-/media/ACR/Files/Practice-Parameters/mr-contrast-breast.pdf. Accessed 28 Aug 2019.
50. Schnall MD, Blume J, Bluemke DA, DeAngelis GA, DeBruhl N, Harms S, et al. Diagnostic architectural and dynamic features at breast MR imaging: multicenter study. Radiology. 2006;238(1):42–53.