American College of Radiology
ACR Appropriateness Criteria®
Breast Cancer Screening

Variant 1: **Breast cancer screening. Average-risk women: women with <15% lifetime risk of breast cancer.**

Procedure	Appropriateness Category	Relative Radiation Level
Mammography screening	Usually Appropriate	☢☢
Digital breast tomosynthesis screening	Usually Appropriate	☢☢
US breast	May Be Appropriate	O
MRI breast without and with IV contrast	Usually Not Appropriate	O
MRI breast without IV contrast	Usually Not Appropriate	O
FDG-PET breast dedicated	Usually Not Appropriate	☢☢☢☢
Sestamibi MBI	Usually Not Appropriate	☢☢☢

Variant 2: **Breast cancer screening. Intermediate-risk women: women with personal history of breast cancer, lobular neoplasia, atypical ductal hyperplasia, or 15% to 20% lifetime risk of breast cancer.**

Procedure	Appropriateness Category	Relative Radiation Level
Mammography screening	Usually Appropriate	☢☢
Digital breast tomosynthesis screening	Usually Appropriate	☢☢
MRI breast without and with IV contrast	May Be Appropriate	O
US breast	May Be Appropriate	O
FDG-PET breast dedicated	Usually Not Appropriate	☢☢☢☢
Sestamibi MBI	Usually Not Appropriate	☢☢☢
MRI breast without IV contrast	Usually Not Appropriate	O

Variant 3: **Breast cancer screening. High-risk women: women with a BRCA gene mutation and their untested first-degree relatives, women with a history of chest irradiation between 10 to 30 years of age, women with 20% or greater lifetime risk of breast cancer.**

Procedure	Appropriateness Category	Relative Radiation Level
Mammography screening	Usually Appropriate	☢☢
Digital breast tomosynthesis screening	Usually Appropriate	☢☢
MRI breast without and with IV contrast	Usually Appropriate	O
US breast	May Be Appropriate	O
FDG-PET breast dedicated	Usually Not Appropriate	☢☢☢☢
Sestamibi MBI	Usually Not Appropriate	☢☢☢
MRI breast without IV contrast	Usually Not Appropriate	O

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Summary of Literature Review

Introduction/Background

Other than skin cancer, breast cancer is the most common cancer diagnosis and the second leading cause of cancer death in women. Since the advent of screening mammography in the United States, breast cancer mortality has decreased 36% between 1989 and 2012, after slowly increasing before that time [1]. Long-term follow-up analysis of populations before and after the institution of screening mammography attributes the decrease in mortality to screening of the general population [2]. In addition to mortality reduction, early detection allows for a wider range of less invasive treatment options.

The sensitivity of mammography is dependent upon breast density, where sensitivity decreases with the increase of breast density. Breast density is reported on mammography as: A = "almost entirely fatty," B = "scattered areas of fibroglandular density," C = "heterogeneously dense," or D = "extremely dense," where "heterogeneously dense" and "extremely dense" (C and D categories) are considered dense [3].

Discussion of Procedures by Variant

Variant 1: Breast cancer screening. Average-risk women: women with <15% lifetime risk of breast cancer.

Mammography and DBT

In follow-up of randomized controlled trials of screening mammography in women 40 to 74 years of age, there continues to be a highly significant decrease in mortality in those randomized to invitation to screening mammography [4]. Because breast cancer incidence increases with age, more women among the younger age group (40-50) will need to be screened for each life saved than for women 50 years of age or older. However, because younger women have a longer life expectancy, life years gained for the women diagnosed with breast cancer by screening in their 40s is higher than in the 50- to 70-year-old population [5]. The age at which various organizations recommend beginning screening mammography and the frequency at which mammography is recommended in different age groups varies based upon the weight given to the perceived risks (false-positive examinations and the possibility of over-diagnosis) and benefits of screening (mortality reduction and less invasive treatment options). Some groups recommend screening for all women starting at age 50, with screening recommended between 40 to 50 years of age dependent upon patient preference [6] or risk [7]. However, personalized screening in the 40 to 49 year age group would cause the majority of screen-detected cancers to be excluded from detection [8,9]. Groups also vary on whether screening mammography is recommended as an annual or biennial examination. Based on a review of the randomized trials and subsequent meta-analyses, the ACR recommends annual screening beginning at 40 years of age [10]. There is no upper age limit established for screening mammography, but as the benefits of screening mammography may take years to be fully realized, screening recommendations should take into account life expectancy and comorbid conditions, with screening mammography remaining appropriate when a woman's life expectancy exceeds 5 to 7 years [10,11].

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Digital breast tomosynthesis (DBT) can address some of the limitations encountered with standard mammographic views. In addition to planar images, DBT allows for creation and viewing of thin-section reconstructed images that may decrease the lesion-masking effect of overlapping normal tissue and reveal the true nature of potential false-positive findings without the need for recall. Several studies confirm that in a screening setting, the cancer detection rate is increased with use of DBT compared with 2-D mammography alone [12-27]. Additionally, the rate of recall for benign findings (false-positives) can be decreased [12,14-17,20-25,27-30]. Some authors found these advantages to be especially pronounced in women under age 50 [20,31], in those with dense breasts [31,32], and with lesion types including spiculated masses [33] and asymmetries [28]. Interpretation time for DBT images is greater than for standard mammography [14,34]. Additionally, dose is increased if standard 2-D images are obtained in addition to DBT images. However, synthesized reconstructed images (a virtual planar image created from the tomographic dataset) may replace the need for a 2-D correlative view; current data suggest that these synthetic images perform as well as standard full-field digital images [35,36]. DBT is almost always performed as part of an examination that also includes digital mammography. The digital mammography part of the examination may be in the form of traditional projection mammography or synthesized image from the DBT data.

US

The presence of dense breast tissue lowers the sensitivity of mammography and increases breast cancer risk when compared with patients with fatty breasts [37]. Adding hand-held or automated breast ultrasound (US) to mammography in women with dense breasts increases the cancer detection rate but also substantially increases the false-positive rate [38-40]. In the initial clinical experience with screening breast US after a dense breast notification law was enacted on a state-wide level, the cancer detection rate increased but the number of short interval follow-up recommendations increased substantially and the positive predictive value of a biopsy recommendation was much lower [41,42]. For women with dense breasts tissue but no additional risk factors, US may be useful as an adjunct to mammography for incremental cancer detection [10], but the balance between increased cancer detection and the increased risk of a false-positive examination should be considered in the decision. There are no data to support the use of US for average-risk women with nondense breasts [43].

MBI and FDG-PET Breast Dedicated

Supplementing mammography with molecular breast imaging (MBI) in women with dense breasts increases the cancer detection rate [44,45]. However, there have been no large population studies of MBI for screening, and the whole-body radiation dose with this technique is concerning [46]. Positron emission tomography with fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG-PET) breast is similarly limited by radiation dose and lack of evidence in large screening populations.

MRI

There is insufficient evidence to support the use of magnetic resonance imaging (MRI) for screening women of average risk.

Variant 2: Breast cancer screening. Intermediate-risk women: women with personal history of breast cancer, lobular neoplasia, atypical ductal hyperplasia, or 15% to 20% lifetime risk of breast cancer.

Some women with an intermediate risk of breast cancer may benefit by beginning screening mammography earlier than 40 years of age and may also benefit from supplemental screening. The recommendations for supplemental screening for women at intermediate risk of breast cancer, including those with a personal history of breast cancer, a history of lobular carcinoma in situ or ADH, those with an intermediate family history and a lifetime risk of 15% to 20%, or women with dense breasts continues to be an area of debate [47].

Mammography and DBT

Annual screening mammography is recommended for women with biopsy-proven lobular neoplasia or atypical ductal hyperplasia beginning at diagnosis, but not when <30 years of age [11]. Women who have a prior history of breast cancer are recommended to have mammography every 12 months (and 6 to 12 months post-radiation if the breast is conserved) [11].

The sensitivity of mammography is dependent upon breast density, with sensitivity decreasing with increasing breast density. DBT can address some of the limitations encountered with standard mammographic views. In addition to planar images, DBT allows for creation and viewing of thin-section reconstructed images that can decrease the lesion-masking effect of overlapping normal tissue and reveal the true nature of potential false-positive findings without the need for recall. Several studies confirm that in a screening setting, cancer detection

rate is increased with the use of DBT compared to 2-D mammography alone [12-27]. Additionally, the rate of recall for benign findings (false-positives) can be decreased [12,14-17,20-25,27-30]. Some authors found these advantages to be especially pronounced in women under age 50 [20,31], in those with dense breasts [31,32], and with lesion types including spiculated masses [33] and asymmetries [28]. Interpretation time for DBT images is greater than for standard mammography [14,34]. Additionally, dose is increased if standard 2-D images are obtained in addition to DBT images. However, synthesized reconstructed images (a virtual planar image created from the tomographic dataset) may replace the need for a 2-D correlative view; current data suggest that these synthetic images perform as well as standard full-field digital images [35,36]. DBT is almost always performed as part of an examination that also includes digital mammography. The digital mammography part of the examination may be in the form of traditional projection mammography or synthesized from the DBT data.

US

In women with dense breasts and increased risk of breast cancer, mammography sensitivity can be as low as 50%; supplementing mammography screening with US will significantly increase cancer detection, although false-positive rates are also substantially increased [48,49]. In intermediate-risk women with dense breasts, supplemental US screening is an option [48,49].

MRI

The American Cancer Society considers there to be insufficient evidence for or against MRI as an adjunct to mammography in women at intermediate risk of breast cancer [47]. However, recent studies support the use of screening MRI in certain subsets of this population, including women with a history of lobular carcinoma in situ [50,51] or a personal history of breast cancer [52,53].

MBI and FDG-PET Breast Dedicated

Supplementing mammography with MBI in women with dense breasts increases the cancer detection rate [44,45]. However, there have been no large population studies of MBI for screening and whole body radiation dose with this technique is concerning [46]. FDG-PET breast is similarly limited by radiation dose and lack of evidence in large screening populations.

Variant 3: Breast cancer screening. High-risk women: women with a BRCA gene mutation and their untested first-degree relatives, women with a history of chest irradiation between 10 to 30 years of age, women with 20% or greater lifetime risk of breast cancer.

Women at high risk for breast cancer include those with BRCA or other known genetic predispositions, women with a very strong family history placing them at more than a 20% lifetime risk of breast cancer, and those with prior mantle radiation therapy between 10 to 30 years of age [47]. In addition to beginning screening mammography earlier than the general population, women in this high-risk group benefit from supplemental screening.

Mammography and DBT

Annual mammography is recommended starting 8 years after radiation therapy but not before age 25 for women who received mantle radiation between 10 to 30 years of age [10,11]. As there is some concern about young women with an inherited cancer predisposition having increased sensitivity to radiation, women with a genetic predisposition are recommended for annual screening beginning 10 years earlier than the affected relative at the time of diagnosis but not before age 30 [11].

The sensitivity of mammography is dependent upon breast density, with sensitivity decreasing with increasing breast density. DBT can address some of the limitations encountered with standard mammographic views. In addition to planar images, DBT allows for creation and viewing of thin-section reconstructed images that may decrease the lesion-masking effect of overlapping normal tissue and reveal the true nature of potential false-positive findings without the need for recall. Several studies confirm that in a screening setting, the cancer detection rate is increased with use of DBT compared to 2-D mammography alone [12-27]. Additionally, the rate of recall for benign findings (false-positives) can be decreased [12,14-17,20-25,27-30]. Some authors found these advantages to be especially pronounced in women under age 50 [20,31], in those with dense breasts [31,32], and those with lesion types including spiculated masses [33] and asymmetries [28]. Interpretation time for DBT images is greater than for standard mammography [14,34]. Additionally, dose is increased if standard 2-D images are obtained in addition to DBT images. However, synthesized reconstructed images (a virtual planar image created from the tomographic dataset) may replace the need for a 2-D correlative view; and current data suggest that these synthetic images perform as well as standard full-field digital images [35,36]. DBT is almost always

performed as part of an examination that also includes digital mammography. The digital mammography part of the examination may be in the form of traditional projection mammography or synthesized image from the DBT data.

MRI

Breast MRI in high-risk women has a higher sensitivity than mammography, and the combination of mammography and MRI in this population has the highest sensitivity [54-61]. In a high-risk population, MRI and mammography combined have a higher sensitivity (92.7%) than US and mammography combined (52%) [49,62]. Therefore, in high-risk women for whom supplemental screening is indicated, MRI is recommended when possible. Screening MRI is recommended in women with BRCA gene mutations and their untested first-degree relatives as well as women with a lifetime risk of breast cancer of ~20% or greater. Also included in this high-risk group are women who have received radiation therapy to the chest between 10 to 30 years of age as well as women with other genetic syndromes that increase the risk of breast cancer.

Screening high-risk women with breast MRI is cost-effective, and the cost-effectiveness of screening MRI increases with increasing breast cancer risk [63,64]. The American Cancer Society recommends breast-screening MRI in high-risk women [47], and the ACR and the Society of Breast Imaging endorse those recommendations [10].

US

Screening US is indicated in high-risk patients who cannot tolerate MRI. Mammography alone does not perform as well as mammography plus supplemental screening in high-risk women, especially those with a genetic predisposition, and supplemental screening US is indicated in high-risk patients who cannot tolerate MRI [49,62].

MBI and FDG-PET Breast Dedicated

Supplementing mammography with MBI in women with dense breasts increases the cancer detection rate [44,45]. However, there have been no large population studies of MBI for screening and the whole-body radiation dose with this technique is concerning [46]. FDG-PET breast is similarly limited by radiation dose and lack of evidence in large screening populations.

Summary of Recommendations

- For average-risk women, annual screening mammography or DBT (with accompanying planar or synthesized 2-D images) is recommended beginning at age 40. For women with dense breasts, US may also be considered, but the balance between increased cancer detection and the increased risk of a false-positive examination should be considered in the decision.
- For intermediate-risk women, breast mammography or DBT (with accompanying planar or synthesized 2-D images) is recommended. MRI may be considered as an adjunct to mammography or DBT (with accompanying planar or synthesized 2-D images) depending upon risk factors. For women with dense breasts, US may be an option, but the balance between increased cancer detection and the increased risk of a false-positive examination should be considered in the decision.
- For high-risk women, mammography or DBT (with accompanying planar or synthesized 2-D images) is recommended. MRI is recommended as an adjunct to screening mammography or DBT (with accompanying planar or synthesized 2-D images). US is recommended when the patient cannot tolerate MRI.

Summary of Evidence

Of the 65 references cited in the *ACR Appropriateness Criteria® Breast Cancer Screening* document, all of them are categorized as diagnostic references including 12 well-designed studies, 12 good-quality studies, and 22 quality studies that may have design limitations. There are 18 references that may not be useful as primary evidence. There is one reference that is a meta-analysis study.

The 65 references cited in the *ACR Appropriateness Criteria® Breast Cancer Screening* document were published from 2005 to 2017.

While there are references that report on studies with design limitations, 24 well-designed or good-quality studies provide good evidence.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document [65].

Relative Radiation Level Designations		
Relative Radiation Level*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".		

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

References

1. Siegel RL, Miller KD, Jemal A. Cancer Statistics, 2017. *CA Cancer J Clin.* 2017;67(1):7-30.

2. Reduction in breast cancer mortality from organized service screening with mammography: 1. Further confirmation with extended data. *Cancer Epidemiol Biomarkers Prev.* 2006;15(1):45-51.
3. D'Orsi CJ, Sickles EA, Mendelson EB, et al. *ACR BI-RADS® Atlas, Breast Imaging Reporting and Data System. Reston, VA, American College of Radiology; 2013.*
4. Tabar L, Vitak B, Chen TH, et al. Swedish two-county trial: impact of mammographic screening on breast cancer mortality during 3 decades. *Radiology.* 2011;260(3):658-663.
5. Hendrick RE, Helvie MA. Mammography screening: a new estimate of number needed to screen to prevent one breast cancer death. *AJR Am J Roentgenol.* 2012;198(3):723-728.
6. Siu AL. Screening for Breast Cancer: U.S. Preventive Services Task Force Recommendation Statement. *Ann Intern Med.* 2016;164(4):279-296.
7. Schousboe JT, Kerlikowske K, Loh A, Cummings SR. Personalizing mammography by breast density and other risk factors for breast cancer: analysis of health benefits and cost-effectiveness. *Ann Intern Med.* 2011;155(1):10-20.
8. Destounis SV, Arieno AL, Morgan RC, et al. Comparison of breast cancers diagnosed in screening patients in their 40s with and without family history of breast cancer in a community outpatient facility. *AJR Am J Roentgenol.* 2014;202(4):928-932.
9. Price ER, Keedy AW, Gidwaney R, Sickles EA, Joe BN. The Potential Impact of Risk-Based Screening Mammography in Women 40-49 Years Old. *AJR Am J Roentgenol.* 2015;205(6):1360-1364.
10. Lee CH, Dershaw DD, Kopans D, et al. Breast cancer screening with imaging: recommendations from the Society of Breast Imaging and the ACR on the use of mammography, breast MRI, breast ultrasound, and other technologies for the detection of clinically occult breast cancer. *J Am Coll Radiol.* 2010;7(1):18-27.
11. Monticciolo DL, Newell MS, Hendrick RE, et al. Breast Cancer Screening for Average-Risk Women: Recommendations From the ACR Commission on Breast Imaging. *J Am Coll Radiol.* 2017;14(9):1137-1143.
12. Ciatto S, Houssami N, Bernardi D, et al. Integration of 3D digital mammography with tomosynthesis for population breast-cancer screening (STORM): a prospective comparison study. *Lancet Oncol.* 2013;14(7):583-589.
13. Bernardi D, Caumo F, Macaskill P, et al. Effect of integrating 3D-mammography (digital breast tomosynthesis) with 2D-mammography on radiologists' true-positive and false-positive detection in a population breast screening trial. *Eur J Cancer.* 2014;50(7):1232-1238.
14. Bernardi D, Ciatto S, Pellegrini M, et al. Application of breast tomosynthesis in screening: incremental effect on mammography acquisition and reading time. *Br J Radiol.* 2012;85(1020):e1174-1178.
15. Caumo F, Bernardi D, Ciatto S, et al. Incremental effect from integrating 3D-mammography (tomosynthesis) with 2D-mammography: Increased breast cancer detection evident for screening centres in a population-based trial. *Breast.* 2014;23(1):76-80.
16. Friedewald SM, Rafferty EA, Rose SL, et al. Breast cancer screening using tomosynthesis in combination with digital mammography. *JAMA.* 2014;311(24):2499-2507.
17. Greenberg JS, Javitt MC, Katzen J, Michael S, Holland AE. Clinical performance metrics of 3D digital breast tomosynthesis compared with 2D digital mammography for breast cancer screening in community practice. *AJR Am J Roentgenol.* 2014;203(3):687-693.
18. Houssami N, Macaskill P, Bernardi D, et al. Breast screening using 2D-mammography or integrating digital breast tomosynthesis (3D-mammography) for single-reading or double-reading--evidence to guide future screening strategies. *Eur J Cancer.* 2014;50(10):1799-1807.
19. Lei J, Yang P, Zhang L, Wang Y, Yang K. Diagnostic accuracy of digital breast tomosynthesis versus digital mammography for benign and malignant lesions in breasts: a meta-analysis. *Eur Radiol.* 2014;24(3):595-602.
20. McCarthy AM, Kontos D, Synnestvedt M, et al. Screening outcomes following implementation of digital breast tomosynthesis in a general-population screening program. *J Natl Cancer Inst.* 2014;106(11).
21. Rafferty EA, Park JM, Philpotts LE, et al. Assessing radiologist performance using combined digital mammography and breast tomosynthesis compared with digital mammography alone: results of a multicenter, multireader trial. *Radiology.* 2013;266(1):104-113.
22. Rafferty EA, Park JM, Philpotts LE, et al. Diagnostic accuracy and recall rates for digital mammography and digital mammography combined with one-view and two-view tomosynthesis: results of an enriched reader study. *AJR Am J Roentgenol.* 2014;202(2):273-281.
23. Rose SL, Tidwell AL, Ice MF, Nordmann AS, Sexton R, Jr., Song R. A reader study comparing prospective tomosynthesis interpretations with retrospective readings of the corresponding FFDM examinations. *Acad Radiol.* 2014;21(9):1204-1210.

24. Skaane P, Bandos AI, Gullien R, et al. Prospective trial comparing full-field digital mammography (FFDM) versus combined FFDM and tomosynthesis in a population-based screening programme using independent double reading with arbitration. *Eur Radiol.* 2013;23(8):2061-2071.
25. Skaane P, Bandos AI, Gullien R, et al. Comparison of digital mammography alone and digital mammography plus tomosynthesis in a population-based screening program. *Radiology.* 2013;267(1):47-56.
26. Svahn TM, Chakraborty DP, Ikeda D, et al. Breast tomosynthesis and digital mammography: a comparison of diagnostic accuracy. *Br J Radiol.* 2012;85(1019):e1074-1082.
27. Takamoto Y, Tsunoda H, Kikuchi M, et al. Role of breast tomosynthesis in diagnosis of breast cancer for Japanese women. *Asian Pac J Cancer Prev.* 2013;14(5):3037-3040.
28. Durand MA, Haas BM, Yao X, et al. Early clinical experience with digital breast tomosynthesis for screening mammography. *Radiology.* 2015;274(1):85-92.
29. Lourenco AP, Barry-Brooks M, Baird GL, Tuttle A, Mainiero MB. Changes in recall type and patient treatment following implementation of screening digital breast tomosynthesis. *Radiology.* 2015;274(2):337-342.
30. Rose SL, Tidwell AL, Bujnoch LJ, Kushwaha AC, Nordmann AS, Sexton R, Jr. Implementation of breast tomosynthesis in a routine screening practice: an observational study. *AJR Am J Roentgenol.* 2013;200(6):1401-1408.
31. Haas BM, Kalra V, Geisel J, Raghu M, Durand M, Philpotts LE. Comparison of tomosynthesis plus digital mammography and digital mammography alone for breast cancer screening. *Radiology.* 2013;269(3):694-700.
32. Mun HS, Kim HH, Shin HJ, et al. Assessment of extent of breast cancer: comparison between digital breast tomosynthesis and full-field digital mammography. *Clin Radiol.* 2013;68(12):1254-1259.
33. Lang K, Andersson I, Zackrisson S. Breast cancer detection in digital breast tomosynthesis and digital mammography-a side-by-side review of discrepant cases. *Br J Radiol.* 2014;87(1040):20140080.
34. Dang PA, Freer PE, Humphrey KL, Halpern EF, Rafferty EA. Addition of tomosynthesis to conventional digital mammography: effect on image interpretation time of screening examinations. *Radiology.* 2014;270(1):49-56.
35. Skaane P, Bandos AI, Eben EB, et al. Two-view digital breast tomosynthesis screening with synthetically reconstructed projection images: comparison with digital breast tomosynthesis with full-field digital mammographic images. *Radiology.* 2014;271(3):655-663.
36. Zuley ML, Guo B, Catullo VJ, et al. Comparison of two-dimensional synthesized mammograms versus original digital mammograms alone and in combination with tomosynthesis images. *Radiology.* 2014;271(3):664-671.
37. Winkler NS, Raza S, Mackesy M, Birdwell RL. Breast density: clinical implications and assessment methods. *Radiographics.* 2015;35(2):316-324.
38. Brem RF, Tabar L, Duffy SW, et al. Assessing improvement in detection of breast cancer with three-dimensional automated breast US in women with dense breast tissue: the SomoInsight Study. *Radiology.* 2015;274(3):663-673.
39. Chae EY, Kim HH, Cha JH, Shin HJ, Kim H. Evaluation of screening whole-breast sonography as a supplemental tool in conjunction with mammography in women with dense breasts. *J Ultrasound Med.* 2013;32(9):1573-1578.
40. Giuliano V, Giuliano C. Improved breast cancer detection in asymptomatic women using 3D-automated breast ultrasound in mammographically dense breasts. *Clin Imaging.* 2013;37(3):480-486.
41. Hooley RJ, Greenberg KL, Stackhouse RM, Geisel JL, Butler RS, Philpotts LE. Screening US in patients with mammographically dense breasts: initial experience with Connecticut Public Act 09-41. *Radiology.* 2012;265(1):59-69.
42. Parris T, Wakefield D, Frimmer H. Real world performance of screening breast ultrasound following enactment of Connecticut Bill 458. *Breast J.* 2013;19(1):64-70.
43. Gartlehner G, Thaler KJ, Chapman A, et al. Adjunct ultrasonography for breast cancer screening in women at average risk: a systematic review. *Int J Evid Based Healthc.* 2013;11(2):87-93.
44. Rhodes DJ, Hruska CB, Conners AL, et al. Journal club: molecular breast imaging at reduced radiation dose for supplemental screening in mammographically dense breasts. *AJR Am J Roentgenol.* 2015;204(2):241-251.
45. Rhodes DJ, Hruska CB, Phillips SW, Whaley DH, O'Connor MK. Dedicated dual-head gamma imaging for breast cancer screening in women with mammographically dense breasts. *Radiology.* 2011;258(1):106-118.
46. Holbrook A, Newell MS. Alternative screening for women with dense breasts: breast-specific gamma imaging (molecular breast imaging). *AJR Am J Roentgenol.* 2015;204(2):252-256.

47. Saslow D, Boetes C, Burke W, 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.
48. 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(18):2151-2163.
49. Berg WA, Zhang Z, Lehrer D, et al. Detection of breast cancer with addition of annual screening ultrasound or a single screening MRI to mammography in women with elevated breast cancer risk. *JAMA.* 2012;307(13):1394-1404.
50. Friedlander LC, Roth SO, Gavenonis SC. Results of MR imaging screening for breast cancer in high-risk patients with lobular carcinoma in situ. *Radiology.* 2011;261(2):421-427.
51. Sung JS, Malak SF, Bajaj P, Alis R, Dershaw DD, Morris EA. Screening breast MR imaging in women with a history of lobular carcinoma in situ. *Radiology.* 2011;261(2):414-420.
52. Lehman CD, Lee JM, DeMartini WB, et al. Screening MRI in Women With a Personal History of Breast Cancer. *J Natl Cancer Inst.* 2016;108(3).
53. Brennan S, Liberman L, Dershaw DD, Morris E. Breast MRI screening of women with a personal history of breast cancer. *AJR Am J Roentgenol.* 2010;195(2):510-516.
54. Hagen AI, Kvistad KA, Maehle L, et al. Sensitivity of MRI versus conventional screening in the diagnosis of BRCA-associated breast cancer in a national prospective series. *Breast.* 2007;16(4):367-374.
55. Kriege M, Brekelmans CT, Boetes C, et al. Differences between first and subsequent rounds of the MRISC breast cancer screening program for women with a familial or genetic predisposition. *Cancer.* 2006;106(11):2318-2326.
56. Kuhl CK, Schrading S, Leutner CC, et al. Mammography, breast ultrasound, and magnetic resonance imaging for surveillance of women at high familial risk for breast cancer. *J Clin Oncol.* 2005;23(33):8469-8476.
57. Leach MO, Boggis CR, Dixon AK, et al. Screening with magnetic resonance imaging and mammography of a UK population at high familial risk of breast cancer: a prospective multicentre cohort study (MARIBS). *Lancet.* 2005;365(9473):1769-1778.
58. Saadatmand S, Vos JR, Hooning MJ, et al. Relevance and efficacy of breast cancer screening in BRCA1 and BRCA2 mutation carriers above 60 years: a national cohort study. *Int J Cancer.* 2014;135(12):2940-2949.
59. Sardanelli F, Podo F, D'Agnolo G, et al. Multicenter comparative multimodality surveillance of women at genetic-familial high risk for breast cancer (HIBCRIT study): interim results. *Radiology.* 2007;242(3):698-715.
60. Kuhl C, Weigel S, Schrading S, et al. Prospective multicenter cohort study to refine management recommendations for women at elevated familial risk of breast cancer: the EVA trial. *J Clin Oncol.* 2010;28(9):1450-1457.
61. Weinstein SP, Localio AR, Conant EF, Rosen M, Thomas KM, Schnall MD. Multimodality screening of high-risk women: a prospective cohort study. *J Clin Oncol.* 2009;27(36):6124-6128.
62. Berg WA. Tailored supplemental screening for breast cancer: what now and what next? *AJR Am J Roentgenol.* 2009;192(2):390-399.
63. Plevritis SK, Kurian AW, Sigal BM, et al. Cost-effectiveness of screening BRCA1/2 mutation carriers with breast magnetic resonance imaging. *JAMA.* 2006;295(20):2374-2384.
64. Taneja C, Edelsberg J, Weycker D, Guo A, Oster G, Weinreb J. Cost effectiveness of breast cancer screening with contrast-enhanced MRI in high-risk women. *J Am Coll Radiol.* 2009;6(3):171-179.
65. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: http://www.acr.org/~/media/ACR/Documents/AppCriteria/RadiationDoseAssessmentIntro.pdf. Accessed September 1, 2017.