Added Value of Digital Breast Tomosynthesis Combined with Digital Mammography According to Reader Agreement: Changes in BI-RADS Rate and Follow-Up Management

Francesca Galati^a Flaminia Marzocca^a Erica Bassetti^a Maria L. Luciani^a Sharon Tan^{a,b}
Carlo Catalano^a Federica Pediconi^a

^aDepartment of Radiological, Oncological and Pathological Sciences – University of Rome ‘Sapienza’, Rome, Italy;

^bTengku Ampuan Rahimah Hospital, Klang, Malaysia

Keywords

Digital mammography · Tomosynthesis ·
BI-RADS classification

Summary

Background: The aim of this study was to evaluate the added value of digital breast tomosynthesis (DBT) when combined with digital mammography (DM) in BI-RADS assessment and follow-up management. **Methods:** From February 2014 to January 2015, 214 patients underwent DM and DBT, acquired with a Siemens Mammomat Inspiration unit. 2 expert readers independently reviewed the studies in 2 steps: DM and DM+DBT, according to BI-RADS rate. Patients with BI-RADS 0, 3, 4, and 5 were recalled for work-up. Inter-reader agreement for BI-RADS rate and work-up rate were evaluated using Cohen’s kappa. **Results:** Inter-reader agreement (κ value) for BI-RADS classification was 0.58 for DM and 0.8 for DM+DBT. DM+DBT increased the number of BI-RADS 1, 2, 4, 5 and reduced the number of BI-RADS 0 and 3 for both readers compared to DM alone. Regarding work-up rate agreement, κ was poor for DM and substantial (0.7) for DM+DBT. DM+DBT also reduced the work-up rate for both Reader 1 and Reader 2. **Conclusion:** DM+DBT increased the number of negative and benign cases (BI-RADS 1 and 2) and suspicious and malignant cases (BI-RADS 4 and 5), while it reduced the number of BI-RADS 0 and 3. DM+DBT also improved inter-reader agreement and reduced the overall recall for additional imaging or short-interval follow-up.

© 2017 S. Karger GmbH, Freiburg

Introduction

Breast cancer is the most common female invasive cancer in Western countries. It represents almost 25% of female cancers, affecting 1 in 10 women. The incidence is ever increasing, mainly due to 3 factors: actual rise in disease rate (30%), increase in the number of early diagnoses due to the use of mammography (60%), and increase in life expectancy with a higher probability of cancer developing (10%). In recent years, in Italy, the breast cancer mortality of under 49-year-old women decreased by almost 11%. This reduction demonstrates the relevance of early diagnosis through breast imaging in order to improve treatment strategies and outcomes [1, 2].

The limits of digital mammography (DM) are well known and are partly related to the 2-dimensional (2D) format of conventional imaging of the 3-dimensional (3D) breast volume. Since some breast cancers have the same X-ray attenuation as normal breast tissue, clinically relevant malignancies may be obscured by overlapping normal tissue. In contrast, complex areas of normal tissue may be perceived as suspicious. The limitations of 2D breast imaging lead to low sensitivity in detecting certain cancers and high false-positive recall rates. Although mammographic screening has been shown to reduce breast cancer deaths by approximately 30%, controversy exists over when and how often screening mammography should occur [3, 4].

Digital breast tomosynthesis (DBT) is an emerging diagnostic technique which provides a 3D reconstruction of the breast, minimizing the effect of overlapping breast tissue and improving the detection of any lesions [5, 6]. At present, DBT is a promising technique, but it is mainly used in women with a positive screening mammography or clinical symptoms. Large-scale studies are still

needed to confirm its role in screening and to introduce this tool into daily practice [7, 8].

The purpose of our study is to assess the advantages of DBT in the assignment of BI-RADS categories [9] and in the management and follow-up of patients compared to mammography alone. Also, an inter-reader agreement study between 2 readers was conducted in order to assess whether the use of DBT could make readings more homogeneous, thus improving the management of patients in clinical practice.

Patients and Methods

The study was approved by the ethics committee of our institution. Objectives and methodology were clearly explained to the patients, and all patients provided written informed consent. Each recruited woman could withdraw from the study at any time. The study was performed independently of any type of industry support (provision of equipment, financial support), and the authors had full control of all data and information submitted for publication.

From February 2014 to January 2015, we enrolled 214 patients aged 36–85 years (mean 51.47 years) from approximately 5,332 women presenting for spontaneous screening mammography.

The study population included symptomatic women, women with dense breasts (American College of Radiology (ACR) BI-RADS c, d [9]), and women who had previously undergone breast surgery for malignant disease. Each patient underwent clinical breast examination, DM, and DBT; the medical history was also evaluated. We decided to exclude from our study asymptomatic patients with predominantly fatty breasts (ACR BI-RADS a, b [9]), patients who carry mutations in *BRCA 1/2* due to the increased radiosensitivity [10, 11], and those with a possible pregnancy.

Patients with suspicious findings underwent fine needle or core biopsy followed by surgery and histopathological examination of the specimens. Patients without suspicious findings were followed for at least 1 year [12, 13] to establish absence of cancer.

Participants underwent DM imaging of both breasts in the mediolateral oblique (MLO) and craniocaudal (CC) position, while DBT imaging was acquired in bilateral MLO projections for patients with dense breast, and in MLO and CC projections on operated breasts only for patients with former breast cancer or symptomatic women.

DBT examinations were performed immediately after the DM examinations, both on the dedicated full-field DM system Siemens MAMMOMAT Inspiration (Siemens AG Healthcare, Erlangen, Germany). This unit has an a-Se detector with 85 μm pitch and a selenium layer thickness of 200 μm . The A/F combination was W/Rh and the tube voltage range was 26–32 kV as determined by the automatic exposure control device of the DM unit. The nominal focal spot dimension was 0.3 mm. The source-to-image receptor distance (SID) was 655.5 mm, while the source-to-breast support table distance (STD) was 637 mm. The system used a linear grid with a ratio of 5:1, lead septa, and strip density of 31 lines/cm [14]. The average dose to the glandular tissues within the breast (average glandular dose, AGD) for a single DBT view was on average factor 1.5 higher than those for a single 2D mammogram. The significance of this dose increase must be assessed in relation to the clinical performance and future role of DBT systems.

Siemens' breast tomosynthesis unit acquires 25 images during a continuous scan, while the X-ray source rotates along a predefined arc of $\pm 25^\circ$ relative to the 0° position around the compressed breast, with a 2° angle increment per image. Images are reconstructed using filtered back projection in order to provide sections parallel to the breast support.

Two breast imaging specialists, with respectively 15 and 10 years' experience in breast imaging, blindly interpreted the DM and DBT images using a dedicated workstation on 2 Nio 5-megapixel MDNG-6121 Barco monitors (Barco, Kortrijk, Belgium). DBT reconstructions were reviewed in cine or manual scroll modes on the dedicated workstation.

Table 1. BI-RADS interpretation and patient management

Interpretation	Management
BI-RADS 0 and 3	recall for additional imaging
BI-RADS 1 and 2	routine mammography screening
BI-RADS 4 and 5	core biopsy or fine needle followed by surgery and histopathological examination of the specimen

Each reader evaluated the images in 2 steps: DM first (at this time, DBT examinations were not available to the radiologist to avoid clinical decision making being affected), and after a period of 2–4 weeks the combined evaluation of DM and DBT views. At the end of 1 reading step, each radiologist gave a probability of breast malignancy using the BI-RADS classification (0–5) [9] and determined the need for further diagnostic investigations (score of 0 no work-up, 1 work-up). Patients with BI-RADS 0, 3, 4, and 5 were recalled for work-up (table 1).

We calculated the percentage of single-reader BI-RADS-assigned categories and the need for further investigation values as determined after DM image reading and after combined DM/DBT view reading. Inter-reader agreement of BI-RADS rate and work-up rate were evaluated using Cohen's kappa in order to verify the reproducibility of the techniques.

Cohen's kappa is a statistic coefficient that measures inter-reader agreement for qualitative (categorical) items. It is generally thought to be a more robust measure than simple percentage agreement calculation, since κ takes into account the agreement occurring by chance. It is calculated from the observed and expected frequencies on the diagonal of a square contingency table. Kappa can range from 0 to +1, where 0 represents the amount of agreement that can be expected from random chance, and 1 represents perfect agreement between the readers.

Results

Of 214 patients, 37 were proven to have cancer, whereas after at least 1 year of follow-up, 177 cases were established to be benign or healthy. Of the 37 cancer patients, 25 had a newly diagnosed breast cancer and 12 had breast cancer recurrence. 21 patients had a single lesion, 7 had multifocal disease, and 9 had multicentric disease, with 59 overall breast lesions. The 59 malignant breast lesions detected in the histologic evaluation were classified as invasive ductal carcinoma ($n = 38$), ductal carcinoma in situ ($n = 7$), invasive lobular carcinoma ($n = 7$), lobular carcinoma in situ ($n = 2$), mucinous carcinoma ($n = 2$), and papillary carcinoma ($n = 3$).

The combined reading of DM with DBT compared to DM alone significantly increased the number of BI-RADS 1 and 2 for both Reader 1 ($p < 0.001$) and Reader 2 ($p < 0.001$). The DM+DBT combination also increased the number of BI-RADS 4 and 5 for Reader 1 ($p < 0.001$) and Reader 2 ($p < 0.001$), while it reduced the number of BI-RADS 0 and 3 for Reader 1 ($p < 0.001$) and Reader 2 ($p < 0.001$) (table 2). The request for further investigations was significantly ($p < 0.001$) reduced with DM+DBT versus DM alone for both Reader 1 and Reader 2 (table 2).

With regard to inter-reader agreement, the BI-RADS classification kappa value was 0.58 for DM (moderate agreement) and 0.8 for DM+DBT (substantial agreement) (table 3). Call-back inter-reader agreement proved to be slight for DM ($\kappa = 0.1$) and substantial for DM+DBT ($\kappa = 0.7$) (table 3).

Table 2. Number of patients according to BI-RADS classification and request for further work-up by reader and modality

	Reader 1, n (%)		Reader 2, n (%)	
	DM	DM+DBT	DM	DM+DBT
BI-RADS 0 and 3	112 (52.34)	17 (7.94)	131 (61.21)	17 (7.94)
BI-RADS 1 and 2	63 (29.44)	129 (60.28)	47 (21.96)	136 (63.55)
BI-RADS 4 and 5	39 (18.22)	68 (31.78)	36 (16.83)	61 (28.51)
Work-up+	184 (85.98)	113 (52.8)	208 (97.2)	118 (55.14)
Work-up-	30 (14.02)	101 (47.2)	6 (2.8)	96 (44.86)

DM = Digital mammography; DBT = digital breast tomosynthesis.

Table 3. Inter-reader agreement (Cohen's kappa value) for BI-RADS assessment and work-up request by modality

	DM	DM+DBT
BI-RADS	0.58	0.8
Work-up+	0.12	0.7

DM = Digital mammography; DBT = digital breast tomosynthesis.

Discussion

DBT involves 3D imaging via mathematically reconstructed sections of breast volume with high spatial resolution; 3D cross-sectional images improve the visibility of breast lesions by reducing superimposition of breast structures, with a resultant increase in cancer detection and reduction in false-positive findings [15].

Evidence from large-scale studies in the US and Europe show that DBT+DM, compared to DM alone, yields higher invasive cancer detection rates, increasing the effectiveness of breast cancer screening [16–19]. Several studies also show that DBT reduces recall rates, thus reducing both costs and distress caused by false-negative recall [20–22].

Methods proposed for DBT imaging include the addition of 1-view tomosynthesis to DM, the addition of 2-view tomosynthesis to DM [23], or a mixture of CC DM and MLO tomosynthesis. Most studies performed 1-view tomosynthesis in MLO acquisition because it generally enables the inclusion of more breast tissue than the CC position, while Rafferty et al. [24], in a recent study, demonstrated a significant gain in diagnostic accuracy with 2-view tomosynthesis, even with an incremental radiation dose.

However, the optimal method for incorporating tomosynthesis into the mammographic workflow is still not defined; hence, we decided to acquire bilateral MLO views for patients with dense breasts, and MLO plus CC views for patients with previous breast cancer surgery and symptomatic patients. The aim of our study was to evaluate the diagnostic potential of DBT compared with DM in clinical practice. In particular, we assessed how DBT used with DM can influence the assignment of BI-RADS categories and the request for further investigations compared to DM alone, possibly reducing non-diagnostic or doubtful cases, such as BI-RADS 0 and 3, and therefore alleviating the need for additional diagnostic tests (ultrasound, magnetic resonance imaging, biopsy) and minimizing patients' anxiety associated with work-up. Moreover, test reproducibility and homogeneity of results are among the most

Fig. 1. 38-year-old woman symptomatic for a lump in her right breast: **a, b** Digital mammography (mediolateral oblique (MLO) and craniocaudal (CC) views) showing a dense breast (ACR d) with circumscribed and benign-appearing masses (BI-RADS 3); **c, d** Digital breast tomosynthesis (MLO and CC views) clearly showing a spiculated mass (BI-RADS 5); surgical pathology confirmed invasive ductal carcinoma.

important features in order to determine the value of a technique; hence, the second purpose of our study was to assess the inter-reader agreement for DM versus DM+DBT.

Our study confirmed the results obtained in previous studies [5, 25, 26]; there was an increase in both true-negative and true-positive cases with DM+DBT compared to DM alone.

We particularly focused on BI-RADS category assignment, because reducing BI-RADS 0 and 3 has pivotal implications for patient care. Our findings showed that DBT+DM significantly reduced the number of cases in these 2 categories (from 58.1 to 8.1%

Fig. 2. 63-year-old woman: Both **a** digital mammography and **b** digital breast tomosynthesis (DBT) mediolateral oblique views show clustered pleomorphic calcifications in the upper quadrants of the left breast (circle); **c** however, DBT also identified a mass under the calcifications confirmed by magnetic resonance imaging; surgical pathology confirmed invasive ductal carcinoma.

for both readers) whilst increasing the number of cases in BI-RADS categories 1 and 2 (from 26.3 to 63.4% for both readers). This leads to lower work-up rates and fewer supplementary breast ultrasounds and unnecessary biopsies. The few studies pertaining to BI-RADS classification currently in the literature provided almost comparable results to our study [27, 28].

More cases were also classified BI-RADS category 4 and 5 with DBT+DM (about 13% more than with DM alone), which means higher cancer detection rates, consistent with the results of prior studies [29, 30]. There was also a significant reduction in false-positive and false-negative cases as also previously reported in the literature [20, 25]. The work-up rate was significantly reduced with DBT+DM versus DM alone (33–42%), similar to previous studies in analogue settings (38.5% for 1-view tomosynthesis [24]).

The inter-reader agreement was substantial for DBT+DM both with regard to BI-RADS assessment and request for further investigation, and was shown to be higher than for DM alone. Our study showed higher agreement and more homogeneous reports, enforcing the reliability of tomosynthesis. To our knowledge, there are no previous studies that investigated this.

The benefits of DBT, according to the 2 readers, were better evaluation of lesion conspicuity due to reduced structure noise from normal breast tissue, margin feature analysis, and detection of additional findings. In the case of a suspicious lesion created by overlapping breast tissue, tomosynthesis was able differentiate normal tissue superimposition from real lesions (fig. 1 and 2) [31, 32]. Concerning calcifications, there are discordant opinions in the literature [33, 34]. Although calcifications are seen with equal or greater clarity on DBT images once they have been detected [26], a cluster of calcification may not be easily perceived with DBT: every single plane can reveal 1 or 2 calcification; consequently, the reader

may not recognize the ‘cluster’. However, DBT was useful in identifying a mass under the calcifications (fig. 2).

Interpretation time was longer for DM+DBT than for DM alone, as also noted by others [6, 35]. However, optimization of interpretation efficiency by means of improved hanging protocols or work-flow is beyond the scope of this investigation.

Some limitations of this study may have biased our results. We enrolled only symptomatic women, women with dense breasts, and women who had previously undergone surgery for breast cancer; therefore, our results may not be representative of the general population. In fact, we scheduled patients with difficult-to-read mammographies due to ‘anatomical noise’ from overlapping glandular tissue or parenchymal distortion caused by surgery. Moreover, we included 214 patients, and, even if we obtained statistically significant results, large-scale studies are needed to confirm them.

Despite these limitations, our study demonstrates that tomosynthesis can reduce the ambiguity of the final diagnosis and possibly increase the rate of both true-negative and true-positive cases, confirming the results of previous studies [24, 36, 37]. This leads to lower work-up rates and fewer supplementary breast ultrasounds and unnecessary biopsies, reducing the relative emotional, financial, and clinical costs [38, 39]. Moreover, adding DBT to DM significantly increased inter-reader agreement, thus improving the performance of radiologists in routine clinical practice.

Disclosure Statement

The authors declare that they have no conflict of interest related to the publication of this article.

References

- Lopez M, Gebbia N, Cascinu S, Marchetti P: *Oncologia Medica Pratica*. Società Editrice Universo, 2010, pp. 1589–1756.
- McPherson K, Steel CM, Dixon JM: ABC of breast diseases. Breast cancer –epidemiology, risk factors, and genetics. *BMJ* 2000;321:624–628.
- Sardanelli F, Aase HS, Alvarez M, Azavedo E: Position paper on screening for breast cancer by the European Society of Breast Imaging (EUSOBI) and 30 national breast radiology bodies. *Eur Radiol* 2017;27:2737–2743.
- Roth RG, Maidment AD, Weinstein SP, Roth SO, Conant EF: Digital breast tomosynthesis: lessons learned from early clinical implementation. *Radiographics* 2014;34:E89–E102.
- Rafferty EA, Park JM, Philpotts LE, Poplack SP, Sumkin JH, Halpern EF, Niklason LT: Assessing radiologist performance using combined digital mammography and breast tomosynthesis compared with digital mammography alone: results of a multicenter, multireader trial. *Radiology* 2016;266:104–113.
- Skaane P, Bandos AI, Gullien R, Eben EB, Ekseth U, Haakenaasen U, Izadi M, Jebsen IN, Jahr G, Krager M, Niklason LT, Hofvind S, Gur D: Comparison of digital mammography alone and digital mammography plus tomosynthesis in a population-based screening program. *Radiology* 2013;267:47–56.
- Lång K, Andersson I, Rosso A, Tingberg A, Timberg P, Zackrisson S: Performance of one-view breast tomosynthesis as a stand-alone breast cancer screening modality: results from the Malmö Breast Tomosynthesis Screening Trial, a population-based study. *Eur Radiol* 2016;26:184–190.
- Bernardi D, Houssami N: Breast cancers detected in only one of two arms of a tomosynthesis (3D-mammography) population screening trial (STORM-2). *Breast* 2017;32:98–101.
- American College of Radiology: ACR BI-RADS® Atlas 5th Edition. ACR, 2013.
- Borrego-Soto G, Ortiz-López R, Rojas-Martínez A: Ionizing radiation-induced DNA injury and damage detection in patients with breast cancer. *Genet Mol Biol* 2015;38:420–432.
- Ernestos B, Nikolaos P, Koulis G, Eleni R, Konstantinos B, Alexandra G, Michael K: Increased chromosomal radiosensitivity in women carrying BRCA1/BRCA2 mutations assessed with the G2 assay. *Int J Radiat Oncol Biol Phys* 2010;76:1199–1205.
- Pisano ED, Hendrick RE, Yaffe MJ, Baum JK, Acharyya S, Cormack JB, Hanna LA, Conant EF, Fajardo LL, Bassett LW, D'Orsi CJ, Jong RA, Rebner M, Tosteson AN, Gatsonis CA; DMIST Investigators Group: Diagnostic accuracy of digital versus film mammography: exploratory analysis of selected population subgroups in DMIST. *Radiology* 2008;246:376–383.
- Gennaro G, Toledano A, di Maggio C, Baldan E, Bezzone E, La Grassa M, Pescarini L, Polico I, Proietti A, Toffoli A, Muzzio PC: Digital breast tomosynthesis versus digital mammography: a clinical performance study. *Eur Radiol* 2010;20:1545–1553.
- Salvagnini E, Bosmans H, Struelens L, Marshall NW: Tailoring automatic exposure control toward constant detectability in digital mammography. *Med Phys* 2015;42:3834–3847.
- Hubbard RA, Kerlikowske K, Flowers CI, Yankaskas BC, Zhu W, Miglioretti DL: Cumulative probability of false-positive recall or biopsy recommendation after 10 years of screening mammography. *Ann Intern Med* 2011;155:481.
- Friedewald SM, Rafferty EA, Rose SL, Durand MA, Plecha DM, Greenberg JS, Hayes MK, Copit DS, Carlson KL, Cink TM, Barke LD, Greer LN, Miller DP, Conant EF: Breast cancer screening using tomosynthesis in combination with digital mammography. *JAMA* 2014;311:2499.
- Houssami N, Skaane P: Overview of the evidence on digital breast tomosynthesis in breast cancer detection. *Breast* 2016;22:101–108.
- Ciatto S, Houssami N, Bernardi D, Caumo F, Pellegrini M, Brunelli S, Tuttobene P, Bricolo P, Fantò C, Valentini M, Montemezzi S, Macaskill P: Integration of 3D digital mammography with tomosynthesis for population breast-cancer screening (STORM): a prospective comparison study. *Lancet Oncol* 2013;14:583–589.
- Baker JA, Lo JY: Breast tomosynthesis: state-of-the-art and review of the literature. *Acad Radiol* 2011;18:1298–1310.
- Hodgson R, Heywang-Köbrunner SH, Harvey SC, Edwards M, Shaikh J, Arber M, Glanville J: Systematic review of 3D mammography for breast cancer screening. *Breast* 2016;27:52–61.
- 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. *Am J Roentgenol* 2014;203:687–693.
- Rafferty EA, Park JM, Philpotts LE, Poplack SP, Sumkin JH: Digital mammography and breast tomosynthesis compared with digital mammography alone: results of a multicenter, multireader trial. *Radiology* 2013;266:104–113.
- Svahn T, Andersson I, Chakraborty D, Svensson S, Ikeda D, Förnvik D, Mattsson S, Tingberg A, Zackrisson S: The diagnostic accuracy of dual-view digital mammography, single-view breast tomosynthesis and a dual-view combination of breast tomosynthesis and digital mammography in a free-response observer performance study. *Radiat Prot Dosimetry* 2010;139:113–117.
- Rafferty EA, Park JM, Philpotts LE, Poplack SP, Sumkin JH, Halpern EF, Niklason LT: 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. *Am J Roentgenol* 2014;202:273–281.
- Conant EF, Beaber EF, Sprague BL, Herschorn SD, Weaver DL, Onega T, Tosteson AN, McCarthy AM, Poplack SP, Haas JS, Armstrong K, Schnall MD, Barlow WE: Breast cancer screening using tomosynthesis in combination with digital mammography compared to digital mammography alone: a cohort study within the PROSPR consortium. *Breast Cancer Res Treat* 2016;156:109–116.
- Kopans DB: Digital breast tomosynthesis from concept to clinical care. *Am J Roentgenol* 2014;202:299–308.
- 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;21:1204–1210.
- Andersson I, Ikeda DM, Zackrisson S, Ruschin M, Svahn T, Timberg P, Tingberg A: Breast tomosynthesis and digital mammography: a comparison of breast cancer visibility and BIRADS classification in a population of cancers with subtle mammographic findings. *Eur Radiol* 2008;18:2817–2825.
- Seo M, Chang JM, Kim SA, Kim WH, Lim JH, Lee SH, Bae MS, Koo HR, Cho N, Moon WK: Addition of digital breast tomosynthesis to full-field digital mammography in the diagnostic setting: additional value and cancer detectability. *J Breast Cancer* 2016;19:438–446.
- Poplack SP, Tosteson TD, Kogel CA, Nagy HM, Poplack SP: Digital breast tomosynthesis: initial experience in 98 women with abnormal digital screening mammography. *AJR* 2007;189:616–623.
- Tagliafico A, Astengo D, Cavagnetto F, Rosasco R, Rescinito G, Monetti F, Calabrese M: One-to-one comparison between digital spot compression view and digital breast tomosynthesis. *Eur Radiol* 2012;22:539–544.
- Noroozian M, Hadjiiski L, Rahnema-Moghadam S, Klein KA, Jeffries DO, Pinsky RW, Chan HP, Carson PL, Helvie MA, Roubidoux MA: Digital breast tomosynthesis is comparable to mammographic spot views for mass characterization. *Radiology* 2012;262:61–68.
- Spangler ML, Zuley ML, Sumkin JH, Abrams G, Ganott MA, Hakim C, Perrin R, Chough DM, Shah R, Gur D: Detection and classification of calcifications on digital breast tomosynthesis and 2D digital mammography: a comparison. *Am J Roentgenol* 2011;196:320–324.
- Kopans D, Gavenonis S, Halpern E, Moore R: Calcifications in the breast and digital breast tomosynthesis. *Breast J* 2011;17:638–644.
- Zuley ML, Bandos AI, Abrams GS, Cohen C, Hakim CM, Sumkin JH, Drescher J, Rockette HE, Gur D: Time to diagnosis and performance levels during repeat interpretations of digital breast tomosynthesis: preliminary observations. *Acad Radiol* 2010;17:450–455.
- Svahn TM, Chakraborty DP, Ikeda D, Zackrisson S, Do Y, Mattsson S, Andersson I: Breast tomosynthesis and digital mammography: a comparison of diagnostic accuracy. *Br J Radiol* 2012;85:e1074–1082.
- Korhonen KE, Weinstein SP, McDonald ES, Conant EF: Strategies to increase cancer detection: review of true-positive and false-negative results at digital breast tomosynthesis screening. *Radiographics* 2016;36:1954–1965.
- Brodersen J, Siersma VD: Long-term psychosocial consequences of false-positive screening mammography. *Ann Fam Med* 2013;11:106–115.
- Brewer NT, Salz T, Lillie SE: Systematic review: the long-term effects of false-positive mammograms. *Ann Intern Med* 2007;146:502.