

Breast Imaging

Architectural distortion in the era of digital breast tomosynthesis: outcomes and implications for management

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ABSTRACT

Purpose: Digital breast tomosynthesis (DBT) has been shown to increase conspicuity of some mammographic findings, particularly architectural distortion (AD). The purpose of this retrospective study was to determine the positive predictive value of AD on diagnostic DBT, and evaluate associations between AD characteristics and histopathologic outcomes.

Methods: This IRB-approved, HIPAA-compliant study included diagnostic DBT exams performed between 1/2014 and 12/2015 that demonstrated AD. Imaging characteristics of AD, corresponding ultrasound and MRI exams, and pathology results were reviewed. Fisher's exact tests and a two-tailed *t*-test were performed.

Results: Seventy-seven cases of AD were visualized in 68 patients (ages 36–78 years, mean 54 years). Core biopsy of 74 cases of AD yielded malignant pathology in 26/74 (35%) tissue samples. Among 48/74 (65%) non-malignant cases of AD, 25 demonstrated a high-risk lesion, including radial scar in 20, with no upgrades to malignancy among 20 high-risk lesions that underwent surgical excision. Among 23 non high-risk causes of benign AD, stromal fibrosis was most common, present in 12 biopsy specimens. Associations between imaging characteristics of AD on DBT and histopathologic outcome were not statistically significant (one-view visualization 3/13 malignant, 10/13 benign, $P = 0.52$; DBT-only finding 1/11 malignant, 10/11 benign, $P = 0.09$). Of 48 cases with an ultrasound correlate, 22/48 (46%) were malignant versus 4/26 (15%) cases without an ultrasound correlate ($P = 0.01$).

Conclusions: AD on diagnostic DBT was malignant in over one-third of cases. The presence of an ultrasound correlate was associated with malignancy.

1. Introduction

The addition of digital breast tomosynthesis (DBT) to standard 2D mammography reduces recall rates [1–4] and improves cancer detection rates of screening mammography [1,2,5,6] compared with standard 2D digital mammography alone. DBT reduces superimposition of fibroglandular tissue, thereby improving visualization of findings that may be subtle or occult on 2D mammography, particularly architectural distortion (AD) [7–9].

AD was shown in a prior study to be the most commonly missed finding among false negative 2D screening mammograms [10]. Improved visualization of AD on DBT therefore has the potential to increase detection of breast malignancy. Improved visualization of AD on DBT may also increase detection of benign processes such as radial scar [11]. Thus, the purpose of this study was to determine the positive

predictive value (PPV) of AD on DBT in combination with 2D mammography and evaluate associations between imaging characteristics of AD and histopathologic outcomes. We also reviewed accompanying breast ultrasound exams to assess whether the presence of an ultrasound correlate was associated with malignancy.

2. Materials and methods

This retrospective study was approved by the Institutional Review Board and compliant with the Health Insurance Portability and Accountability Act. Written informed consent was waived.

2.1. Inclusion criteria

Between January 2014 and December 2015, 4,387 DBT exams

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(2,494 screening, 1,893 diagnostic) with accompanying 2D mammography were performed. Reports of all 1,893 diagnostic DBT exams were reviewed for the term “architectural distortion” within the impression. Cases were reviewed by a Mammography Quality and Standards Act-qualified breast imager with 9 years of experience (LW) and included in this study if AD was confirmed on diagnostic DBT images. Cases of AD with an associated mass, calcifications, or asymmetry were excluded, as were cases of post-surgical AD. Biopsy and final surgical pathology were reviewed. Cases without core needle biopsy or surgical pathology were excluded from statistical analysis.

2.2. Imaging technique, interpretation, and diagnosis

Mammographic examinations were performed utilizing a Selenia Dimensions system (Hologic, Bedford, Mass). During the study period, tomosynthesis was being integrated into the screening workflow, with some patients undergoing 2D screening exams and others undergoing a screening tomosynthesis exam (2D and tomosynthesis views in the CC and MLO projections with synthetic 2D reconstructions). Patients recalled from screening for further evaluation of suspected AD, and patients with suspected AD after presenting for diagnostic imaging with other indications, underwent diagnostic DBT as per the interpreting radiologist. All screening and diagnostic exams were interpreted in the clinical setting by any one of fourteen dedicated breast imagers with 1.5–30 years of experience, all of whom were certified according to the Mammography Quality Standards Act. Twelve of the fourteen participating radiologists were fellowship-trained in breast imaging; the two who were not fellowship-trained had 25 and 30 years of experience in breast imaging.

Ultrasound examinations were performed by the same radiologist interpreting the diagnostic mammogram utilizing a 17–5 MHz transducer (IU22 Ultrasound System; Philips Healthcare, Amsterdam, Netherlands). In cases of suspicious AD with no 2D mammogram or ultrasound correlate, stereotactic biopsy was attempted using mammographic landmarks. If unsuccessful, MRI was performed for further evaluation. Dynamic contrast-enhanced breast MR imaging was performed as a bilateral acquisition with a 1.5 Tesla magnet. Breast MRIs were interpreted by any one of fourteen dedicated breast imagers.

All cases of AD, unless related to prior surgery, required tissue sampling. Histologic diagnosis was obtained through core needle biopsy with marker placement, and in malignant, high-risk, or discordant cases, subsequent needle localization and surgical excision was performed. Core biopsy was performed under mammographic, sonographic, or MRI guidance. During the time of this study, tomosynthesis-guided biopsy was not yet available at our institution.

2.3. Image analysis

One- versus two-view visualization of AD on diagnostic DBT and cases of DBT-only AD (AD not visualized on 2D mammography) were identified by review of radiology reports and verified by the breast imager who reviewed cases for inclusion in this study. Post-biopsy mammograms were reviewed to assess for expected biopsy changes and marker placement at the site of AD.

2.4. Statistical analysis

Two-tailed Fisher's exact tests and a two-tailed *t*-test were performed to assess relationships between imaging features of AD on DBT and histopathologic outcomes, and the potential significance of an ultrasound correlate for AD. A $P < 0.05$ was considered to denote statistical significance.

3. Results

During this two-year period, 77 unique cases of AD were identified

on diagnostic DBT in 68 patients (ages 36–78 years, mean 54 years). Indications for diagnostic DBT in these 68 patients were recall from screening mammography for suspected AD in 57, asymptomatic lumpectomy follow-up in 7, palpable abnormality in 1, follow-up of probably benign findings in 1, nipple discharge in 1, and second opinion for newly diagnosed ductal carcinoma in situ in 1. Core needle biopsy of 74/77 (96%) cases of AD was performed using ultrasound guidance in 48/74 (65%) cases and stereotactic guidance in 22/74 (30%) cases. In 4/74 (5%) cases without an ultrasound correlate, AD could not be localized at the time of stereotactic biopsy; MRI correlates were identified and biopsied under MR guidance in these 4 cases. In one patient, there were 5 areas of AD, 2 of which were biopsied and yielded benign findings; the remaining 3 were followed by DBT and stable at 2-year follow-up after MRI demonstrated no suspicious findings. The 74 cases of AD on DBT with available histopathology were evaluated in this study.

3.1. Malignant architectural distortion

Of the 74 cases, 26/74 (35%) yielded malignant results, including invasive ductal carcinoma (IDC) in 13, invasive lobular carcinoma (ILC) in 9 (Fig. 1), and ductal carcinoma in situ (DCIS) in 4. Low or intermediate grade cancers were identified in 25/26 (96%) malignant cases.

3.2. High-risk architectural distortion

Among 48/74 (65%) non-malignant cases of AD, 25 demonstrated a high-risk lesion on core biopsy, including radial scar in 18 (Figs. 1, 2), radial scar with atypical lobular hyperplasia in 1, radial scar with flat epithelial atypia in 1, atypical ductal hyperplasia in 2, atypical lobular hyperplasia in a background of stromal fibrosis in 1, flat epithelial atypia in 1, and intraductal papilloma in a background of sclerosing adenosis in 1. Of the 25 high-risk lesions, 20/25 (80%) were excised, with no upgrades to malignancy. In one case of radial scar, the patient declined surgical excision; mammography was stable at 2-year follow-up. Three cases of radial scar in one patient were not excised due to concerns regarding insurance and were mammographically stable at 2-year follow-up. Core biopsy of one radial scar was complicated by hematoma and breast surgery opted against excision; follow-up was not available for this patient.

3.3. Benign non high-risk architectural distortion

Of the remaining 23 benign non high-risk cases of AD, dominant pathologies included stromal fibrosis in 12 (Fig. 3), sclerosing adenosis in 5, fat necrosis in 4, and chronic inflammation in 2. One case of stromal fibrosis was considered discordant after core biopsy and subsequently confirmed benign at surgical excision.

Outcomes of AD confirmed at diagnostic DBT are summarized in Table 1.

3.4. Imaging associations with malignancy

Imaging characteristics of AD on DBT were not significantly associated with a malignant or benign histopathologic outcome (Table 2). Specifically, AD was visualized on one view only in 13/74 (18%) cases (6 biopsied by ultrasound, 6 by stereotactic guidance, 1 by MRI), 3 (23% of which were malignant and 10 (77%) of which were benign ($P = 0.52$). Of these one-view findings, 10/13 (77%) were visualized on the CC view, including all 3 one-view malignancies (2 ILC, 1 IDC). Among 11/74 (15%) cases of DBT-only AD not seen on 2D mammography (6 biopsied by ultrasound, 4 by stereotactic guidance using mammographic landmarks, 1 by MRI), 1/11 (9%) yielded malignant pathology (1 ILC) and 10/11 (91%) yielded benign results ($P = 0.09$).

Diagnostic ultrasound was performed to assess for a sonographic correlate for AD in all 74 cases. A sonographic correlate was identified

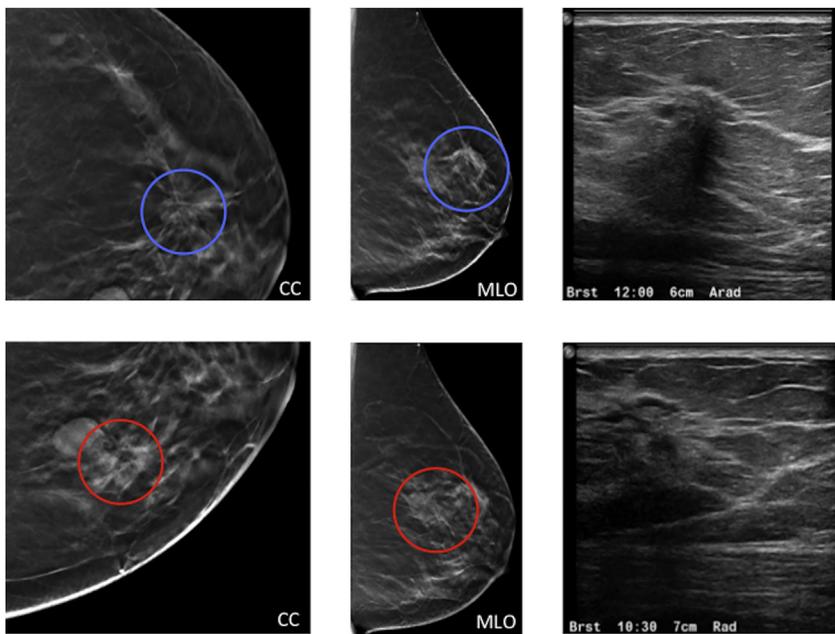


Fig. 1. 48-year-old woman recalled from screening mammography for evaluation of architectural distortion in the upper slightly outer left breast.

Top row: Architectural distortion was confirmed at diagnostic digital breast tomosynthesis (blue circles). An area of distortion was identified on diagnostic ultrasound at the 12:00 position and subsequently biopsied, yielding grade 1 invasive lobular carcinoma.

Bottom row: A second area of architectural distortion was identified at diagnostic digital breast tomosynthesis in the upper inner left breast (red circles). An area of distortion was identified on diagnostic ultrasound at the 10:30 position and subsequently biopsied, yielding radial scar. There was no upgrade of radial scar at bracketed lumpectomy.

CC = craniocaudal; MLO = mediolateral oblique. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

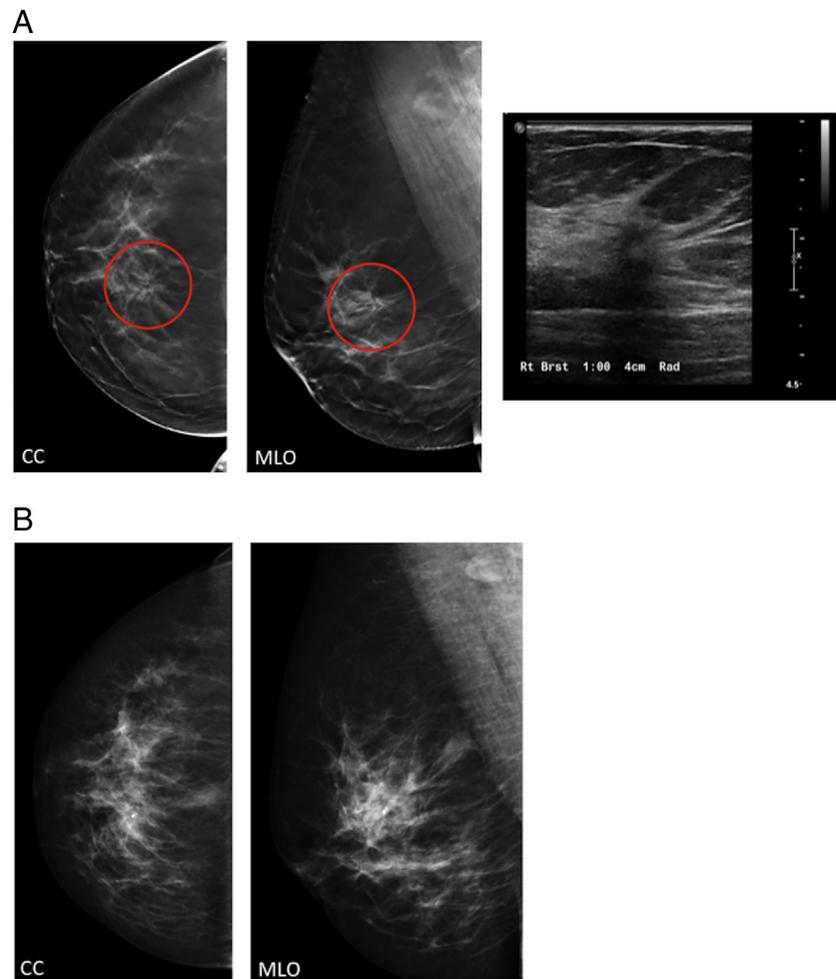


Fig. 2. (A) 41-year-old woman recalled from screening mammography for evaluation of architectural distortion in the upper inner right breast. The finding was confirmed at diagnostic digital breast tomosynthesis. An ill-defined sonographic correlate was identified and subsequently biopsied, yielding radial scar. (B) Post-biopsy mammogram demonstrates the biopsy marker in the expected location. There was no upgrade at excision. CC = craniocaudal; MLO = mediolateral oblique.

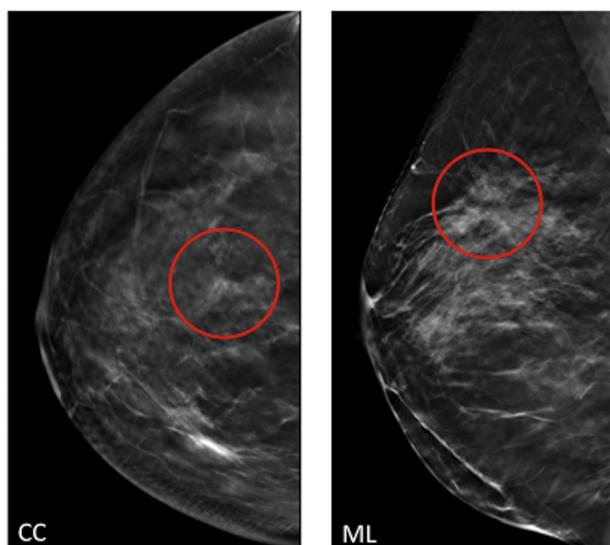


Fig. 3. 44-year-old woman recalled from screening mammography for evaluation of architectural distortion in the upper outer right breast. The finding was confirmed at diagnostic digital breast tomosynthesis. A sonographic correlate was not identified. Subsequent stereotactic-guided core biopsy yielded stromal fibrosis. CC = craniocaudal; ML = mediolateral.

Table 1
Outcomes of architectural distortion confirmed at diagnostic digital breast tomosynthesis (n = 74).

Malignant (n = 26/74; 35%)
Invasive ductal carcinoma (n = 13)
Invasive lobular carcinoma (n = 9)
Ductal carcinoma in situ (n = 4)
High-risk (n = 25/74; 34%)
Radial scar (n = 18)
Radial scar with atypical lobular hyperplasia (n = 1)
Radial scar with flat epithelial atypia (n = 1)
Atypical lobular hyperplasia (n = 2)
Atypical lobular hyperplasia with stromal fibrosis (n = 1)
Flat epithelial atypia (n = 1)
Intraductal papilloma with sclerosing adenosis (n = 1)
Benign non high-risk (n = 23/74; 31%)
Stromal fibrosis (n = 12)
Sclerosing adenosis (n = 5)
Fat necrosis (n = 4)
Chronic inflammation (n = 2)

Table 2
Architectural distortion on digital breast tomosynthesis (DBT): Imaging features and outcomes in 74 cases.

	Malignant: n = 26	Benign: n = 48	P
One-view finding			0.52
Yes (n = 13)	3	10	
No (n = 61)	23	38	
DBT-only finding			0.09
Yes (n = 11)	1	10	
No (n = 63)	25	38	
Ultrasound correlate			0.01
Yes (n = 48)	22	26	
No (n = 26)	4	22	

in 48/74 (65%) cases, including 44 masses (mean size 0.9 ± 0.3 cm) with associated AD, and 4 cases of AD without a clearly demonstrable mass. Of the 48 cases of AD with a sonographic correlate, 22/48 (46%) demonstrated malignant pathology on ultrasound guided biopsy. Of the 26/74 (35%) cases of AD without a sonographic correlate, 22 were biopsied using stereotactic guidance and 4 using MRI guidance,

yielding 4/26 (15%) cases with malignant pathology. The presence of an ultrasound correlate for AD on DBT was significantly associated with malignancy (P = 0.01).

4. Discussion

As clinical use of DBT increases [12–14], the detection of AD is also anticipated to rise [7–9]. Evaluation of histopathologic outcomes of AD on DBT and associated imaging features may be useful for guiding radiologists' levels of suspicion and assessing radiologic-pathologic concordance in the DBT era. In the current study, tissue sampling of 74 cases of AD confirmed on diagnostic DBT yielded a PPV for malignancy of 35%. The high PPV of AD on DBT indicates that tissue sampling is required.

Recent studies have assessed the PPV of AD on DBT, with results similar to our study. In a series of 274 cases, Bahl et al. reported a PPV of AD on DBT of 50.7% [11]. The PPV of AD on DBT appears lower than that on conventional DM, which has been reported to be greater than 70% [11,15]. This suggests that DBT detects AD not only more frequently than DM, but also more frequently secondary to benign processes. However, as described in this study and by Bahl et al. in 2017 [11], the PPV of AD on DBT is high and necessitates tissue sampling.

Feature analysis of AD on DBT did not demonstrate significant association between imaging findings and histopathologic outcome. However, of 13 cases in which AD was seen on one view only, 3/13 (23%) proved malignant; a comparison for these findings could not be found in the literature. The majority of one-view AD were identified on the craniocaudal view, including all 3 one-view malignancies. Two of the 3 one-view malignancies were invasive lobular carcinomas, similar to a prior study [16]; invasive lobular carcinoma was also identified in the lone DBT-only malignancy in this cohort. Other studies have reported the PPV of AD visualized only on DBT, including a series of 14 cases with a PPV of 36% described by Ray et al. [9], and a series of 9 cases with a PPV of 44% described by Partyka et al. [7]. Ariaratnam et al. reported a PPV of 18.8% among 16 cases of DBT-detected AD occult on 2D mammography and ultrasound using DBT-guided biopsy [17], and Alshafeity et al. reported a lower PPV of DBT-only AD of 10.2% among 59 cases, similar to 1/11 (9%) in our series, and still warranting biopsy [18]. Recently, Vijapura et al. reported features of AD on DBT that were associated with benignity, including symmetric spiculation, central lucency, and absence of a sonographic correlate [19]. Further studies are needed to help distinguish benign from malignant AD.

Regarding a sonographic correlate for AD on DBT, 4/26 (15%) cases of AD without a sonographic correlate in this study were malignant. While lower than the 29.2% reported in a study by Bahl et al., in which cases of AD with associated asymmetry or calcifications were included [11], the 15% likelihood of malignancy in cases of AD without a sonographic correlate in this study exceeds the less than 2% threshold considered appropriate for follow-up per the Breast Imaging Data and Reporting System [20]. In this study, one-view AD, DBT-only AD, and AD without a sonographic correlate thus met criteria for low or moderate suspicion for malignancy [20], indicating the importance of pursuing histologic diagnosis in such cases. Meanwhile, the presence of an ultrasound correlate was significantly associated with malignancy. Together, AD on DBT with an ultrasound correlate demonstrated a PPV of 46%, similar to the 66.5% reported by Bahl et al., who also observed a significant association between the identification of an ultrasound correlate for AD and the presence of malignancy [11].

A limitation of this study, and comparison with other similar studies, is the subjective nature of evaluating AD on DBT. The sample size of 74 cases in this study, while of moderate relative size when compared with other reports of AD on DBT in the literature [7,9,11,17,18], remains small. The retrospective findings reported here are those of a single institution using a single DBT manufacturer, and thus require further investigation before they may be considered generalizable.

5. Conclusions

AD on DBT was malignant in over one-third of cases, demonstrating that tissue sampling is required, including for one-view findings, DBT-only findings, and cases of AD without an ultrasound correlate. The presence of an ultrasound correlate was significantly associated with malignancy, and should raise the radiologist's level of suspicion.

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