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ORIGINAL ARTICLE – BREAST ONCOLOGY

Differences in Re-excision Rates for Breast-Conserving Surgery Using Intraoperative 2D Versus 3D Tomosynthesis Specimen Radiograph

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ABSTRACT

Background. Intraoperative specimen radiographs performed during breast conservation surgery for cancer reduces the need for re-excision for positive margins. We studied 2D versus 3D image-guided cavity margin excision and compared it to final pathology and need for additional surgery.

Methods. We conducted a retrospective review of 657 breast-conserving operations performed for cancer from 2013 to 2018. Procedures were performed by four surgeons at a single tertiary institution with access intraoperatively to 2D and 3D radiographs. Data collected included demographics, intraoperative margin assessment, final pathology, and re-excision rates.

Results. A total of 466 patients had 2D and 191 had 3D specimen imaging. The 2D group had a lower mean age and a higher body mass index and proportion of minority patients than the 3D group ($P < 0.01$). In the 3D group, there was a higher percentage of patients with mammographically denser breasts ($P < 0.06$); 58% of patients in the 3D group had additional imaging-directed cavity margins excised versus 32% of patients in the 2D group ($P < 0.01$). In the 2D group, 44 patients (9%) had positive final margins versus 8 patients (4%) in the 3D group ($P = 0.02$). No difference was found on total volume of excision ($P = 0.56$). The re-excision rate for the 2D group was 11% versus 5% for the 3D group ($P = 0.02$; adjusted odds ratio = 0.41, 95% confidence interval 0.19–0.86).

Conclusions. Re-excision rates using both modalities are low. A lower re-excision rate is independently associated with 3D tomosynthesis. This allows surgeons to excise additional margins at the index operation, decreasing reoperations and anxiety/costs for patients.

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In women with early-stage breast cancer, breast conservation with adjuvant radiation has equivalent overall survival compared with mastectomy.[1–6] During a breast-conserving procedure, the tumor with surrounding uninvolved tissue is removed. To be a successful procedure, negative margins need to be obtained to decrease recurrence risk, while ensuring cosmesis.[7–14] If margins are positive, then additional surgical procedures are required, re-excision of margins, or a mastectomy. Additional surgery has added risks for patients, including increased anxiety and costs and worsened cosmetic outcomes, and can delay initiation of adjuvant treatment. In addition, higher volumes of breast tissue are removed with additional surgery than when an adequate single primary excision is performed.[12,15] Intraoperative margin assessment has been shown to decrease the need for additional surgery.[12] An intraoperative specimen radiograph is commonly used to ensure the target lesion has been removed and for margin assessment.[16–19] Specimen radiography is strongly recommended by the American Society of Breast Surgeons.[20] At our institution, surgeons review specimen radiographs in the operating room without radiologist consultation for margin assessment using two-dimensional (2D) or three-dimensional (3D) specimen radiographs. The surgeons excise the lesion of interest (main specimen), then perform and interpret an intraoperative radiograph (2D or 3D) of this specimen, and remove additional margins selectively based on their assessment of margins guided by the imaging. The purpose of our study was to review the intraoperative decision-making of surgeons based on their assessment of 2D versus 3D radiographs of the main specimen removed to direct additional margin excision at the index operation and to compare final histopathology and the need for additional surgery.

METHODS

This was a retrospective study of female patients aged ≥18 years diagnosed with breast cancer who underwent breast-conserving surgery from December 2013 to October 2018. This study was approved by the UT Southwestern institutional review board. Data collected included demographics, clinicopathologic tumor characteristics, preoperative imaging and surgical characteristics, final histopathology, and re-excision rates.

All patients were evaluated preoperatively with a clinical breast exam and at least a mammogram prior to surgery ± ultrasound. Nonpalpable lesions were localized either with iodine-125 titanium radioactive seed (RS) or wire localization (WL). The operations were performed by four fellowship-trained surgeons.

A clear margin for invasive cancer was defined as no tumor on ink.[21] For ductal carcinoma in situ (DCIS), a margin was classified as positive if ink on tumor, close if it was < 2 mm and as negative if ≥ 2 mm, in accordance with consensus guidelines.[22]

The volume of excision was calculated for main specimens using the formula for an ellipsoid, and for excised margins, using the formula for an elliptical cylinder.[23] If oncoplastic closure was performed by a plastic surgeon, the additional volume of excised tissue was not included in calculations.

Intraoperative specimen radiograph was performed in the operating room at a safety-net hospital using a 2D x-ray device (Trident system; Hologic, Marlborough, MA) and at a private university hospital using 2D and 3D tomosynthesis (both using a Mozart system; Kubtec Medical Imaging, Stratford, CT). For both methods of assessment, the specimen was placed in the device and auto-exposed without any compression of tissue. All specimens were marked with orienting sutures. For 2D imaging, an anteroposterior dimension image was taken, followed by the rotation of the specimen 90° about the lateral suture to evaluate anterior and posterior margins. For 3D imaging, the specimen can be viewed by scrolling through the image at 1-mm interval thin slices removing adjacent tissue overlay. In a 2D image, adjacent tissue overlay can mislead the surgeon about the adequacy of margins.

We compared patient demographics, tissues characteristics, histology, and re-excision rates between 2D and 3D using a two-tailed Student's *t* test and the chi-squared test for continuous and categorical variables, respectively. Multivariable logistic regression was performed to determine which variables were independently associated with the re-excision rate. During the study period, only one surgeon used 3D. To address the surgeon effect on re-excision rates, we performed a sensitivity analysis using a subpopulation of patients who underwent excision, with either 2D or 3D, by this one surgeon. We compared patient, specimen characteristics, and re-excision between those who underwent 2D and 3D imaging. In a similar fashion to above, we evaluated the association between imaging type and re-excision rates in the subpopulation. Statistical analyses were done using STATA statistical software (StataCorp, College Station). A P value < 0.05 was considered statistically significant.

RESULTS

Patient and Preoperative Tumor Characteristics

In all, 657 patients underwent breast conservation: 466 patients had 2D (323 at the safety net hospital, 143 at the private hospital) and 191 (all at a private hospital) had 3D intraoperative specimen assessment (Table 1). The 2D group had slightly younger patients (59 vs. 62 years), higher BMI (32 vs. 27 kg/m^2), and higher percentage of minority patients (68 % vs. 29%) (all $P < 0.001$). The 3D group had a higher percentage of heterogeneously dense and extremely dense breasts (44% vs. 35%; $P = 0.062$). No significant difference was found on hormone receptor status; both groups had a high percentage of estrogen and progesterone receptor-positive and Her2Neu receptor-negative cancers. Additionally, both groups had similar a Ki67 proliferation index, tumor grade, and absence of lymphovascular invasion. The 2D group had a similar distribution of mammographic findings, except the 2D group had a higher percentage of mass with calcifications (9% vs. 3% in the 3D group; $P = 0.019$). The 2D group had more cases of DCIS (26% vs. 19% in the 3D group), with a similar distribution of other tumor histologies ($P = 0.077$). More patients in the 3D group had a preoperative MRI available (48% vs. 33% in the 2D group; $P < 0.001$). Preoperative image lesion size and presence of multifocal disease was similar among both groups. More

TABLE 1 Patient and preoperative tumor characteristics

	2D group Total = 466 *n* (%)	3D group Total = 191 *n* (%)	*P* value
Age (yr) mean ± SD	59 ± 11	62 ± 11	< 0.001
BMI (kg/m^2) mean ± SD	32 ± 7	27 ± 6	< 0.001
Race			< 0.001
White	150 (32)	136 (71)	
Black	141 (30)	18 (10)	
Hispanic	158 (34)	8 (4)	
Asian	17 (4)	29 (15)	
Estrogen receptor positive	379 (81)	166 (87)	0.084
Progesterone receptor positive	340 (73)	152 (80)	0.082
Her2Neu receptor positive	47 (13)	18 (12)	0.651
Ki67 mean ± SD	31± 26	29 ± 24	0.477
Tumor grade			0.653
1	131 (28)	45 (24)	
2	205 (44)	90 (48)	
3	127 (28)	53 (28)	
Presence of LVI	32 (7)	13 (7)	0.999
Mammographic density			0.062
Entirely fatty	17 (4)	7 (4)	
Scattered fibroglandular	284 (61)	99 (52)	
Heterogeneously dense	159 (34)	79 (41)	
Extremely dense	6 (1)	6 (3)	
Mammographic finding			0.019
Mass	249 (53)	101 (54)	
Focal asymmetry/density	86 (19)	46 (24)	
Calcifications	89 (19)	36 (19)	
Mass with calcifications	42 (9)	5 (3)	
Preoperative core biopsy diagnosis			0.077
Ductal carcinoma in situ	120 (26)	36 (19)	
Invasive ductal carcinoma	301 (64)	128 (67)	
Invasive lobular carcinoma	22 (5)	17 (9)	
Other*	23 (5)	10 (5)	
Preoperative MRI available	154 (33)	92 (48)	< 0.001
Multifocal/multicentric disease present	71 (15)	23 (12)	0.279
Preoperative size of lesion (cm) no NAT mean ± SD	2.41 ± 1.92	2.35 ± 1.86	0.722
Receipt of NAT			< 0.001
None	358 (77)	139 (73)	
Chemotherapy	103 (22)	36 (19)	
Hormonal	5 (1)	16 (8)	
Preoperative size of lesion (cm) after NAT mean ± SD	2.03 ± 2.03	1.82 ± 1.61	0.532

BMI body mass index; *SD* standard deviation; *LVI* lymphovascular invasion; *NAT* neoadjuvant therapy

*Other: includes invasive mucinous, papillary, mammary, and adenoid cystic carcinomas

patients in the 2D group received neoadjuvant chemotherapy, while more patients in 3D group received neoadjuvant hormonal therapy ($P < 0.001$).

Surgical and Final Pathologic Characteristics

In both groups, most patients underwent radioactive seed-guided localizations for nonpalpable lesions; however, the 2D group had more wire localizations (17% vs.

2% in the 3D group; $P < 0.001$; Table 2). There was no difference in the number of bracketed cases performed; if bracketing was done, most often, only two seeds were used in both groups. Of the 3D patients, 24% underwent oncoplastic reduction at the index operation compared with 4% of patients in the 2D group ($P < 0.001$). However, most patients had only a tissue rearrangement, and no additional tissue was removed by a plastic surgeon. Also, the preoperative lesion size, which guides extent of resection, was similar among both groups (2.09 ± 0.82 cm in 2D vs. 1.97 ± 0.13 cm in 3D, $P = 0.418$). There was no difference in tumor type on final surgical pathology and tumor size.

In the 2D group, 148 patients (32%) underwent image-guided cavity excision compared with 110 patients (58%) in the 3D group ($P < 0.001$). In 45 patients (30%) from 2D group and 24 patients (22%) in 3D group, the additional margin excised correlated with having a positive or close margin in the main specimen. In 7 patients (5%) from 2D group and 12 patients (11%) from 3D group, the additional excised margins had cancer but would have had negative final margins if no additional margins were removed. In the

TABLE 2 Surgical and final pathologic characteristics

	2D group Total = 466 *n* (%)	3D group Total = 191 *n* (%)	*P* value
Method of localization			< 0.001
Seed	364 (79)	183 (96)	
Wire	79 (17)	4 (2)	
None (palpable)	17 (4)	4 (2)	
Bracketed cases	99 (22)	53 (28)	0.093
Oncoplastic closure			< 0.001
Yes	18 (4)	45 (24)	
No	448 (96)	146 (76)	
Final pathology			0.222
Ductal carcinoma in situ	99 (21)	31 (16)	
Invasive ductal carcinoma	307 (66)	129 (68)	
Invasive lobular carcinoma	27 (6)	18 (9)	
Other*	33 (7)	13 (7)	
Final invasive tumor size (cm), mean ± SD	1.38 ± 1.22	1.21 ± 1.06	0.128
Final in situ tumor size (cm), mean ± SD	1.84 ± 2.21	2.36 ± 3.04	0.306
Invasive with in situ component			0.842
Yes	230 (66)	104 (65)	
No	119 (34)	56 (35)	
Size (cm) of intraductal component, mean ± SD	0.78 ± 1.55	0.58 ± 1.21	0.162
Directed margin excision			< 0.001
Yes	148 (32)	110 (58)	
No	318 (68)	81 (42)	
Final margins positive			0.024
Yes	44 (9)	8 (4)	
No	422 (91)	183 (96)	
Re-excision performed			0.014
Yes	50 (11)	9 (5)	
No	416 (89)	182 (95)	
Volume main specimen (cm^3), mean ± SD	99.37 ± 201.14	91.94 ± 88.14	0.623
Volume additional margins (cm^3), mean ± SD	19.52 ± 21.98	41.12 ± 108.52	0.014
Total volume at index operation (cm^3), mean ± SD	106.28 ± 201.56	115.62 ± 145.97	0.562
Volume of re-excision (cm^3), mean ± SD	74.23 ± 94.55	25.42 ± 13.70	0.259
Total volume index + re-excision (cm^3), mean ± SD	113.45 ± 205.32	116.29 ± 145.79	0.862

SD standard deviation; *LVI* lymphovascular invasion; *NAT* neoadjuvant therapy

*Other: includes invasive mucinous, papillary, mammary, and adenoid cystic carcinomas

2D group, 37 patients (25%) had cancer in the additional margins removed; of which, 33 patients had a negative excised margins and 4 patients had positive excised margins. Twenty-six patients were able to avoid a reoperation. Of the 111 patients who had no cancer in the additional margins excised, 8 had other positive margins. For the 3D group, 19 patients (17%) had cancer in the additional margins excised, of which 18 patients had a negative excised margin and 1 patient had a positive excised margin. Sixteen of those 18 patients avoided a reoperation, while the other 2 had other positive margins needing surgery. In the remaining 91 patients whose additional margins did not have cancer, only 2 patients had other positive margins needing surgery.

A total of 44 patients (9%) in the 2D group had final positive margins compared with only 8 patients (4%) in the 3D group at the index operation (P = 0.024). In the majority of cases, only one final margin was positive in both groups. For the 2D group, 34 cases had one positive margin, 7 cases had two positive margins, and 3 cases had extensive DCIS with multiple positive margins. For the 3D group, five cases had one positive margin, one case had two positive margins, and two cases had multiple positive margins.

The re-excision rate was 11% (50 patients) in the 2D group compared with 5% (9 patients) in the 3D group (P = 0.014). In the 2D group, 39 patients with positive margins and 11 patients with close multiple margins to DCIS underwent re-excision. In the 3D group, one patient with positive margin declined excision, whereas two re-excisions included two patients with close margin to DCIS (extensively present). Of the patients who underwent additional surgery, most underwent re-excision of margins (45 patients in 2D vs. 5 patients in 3D group). Four patients in the 2D group and four patients in the 3D group underwent mastectomy. One patient in the 2D group underwent re-excision with additional positive margins and underwent a mastectomy.

The 2D group had a larger main volume in the tumor specimen (a mean of 99.37 cm^3 vs. 91.94 cm^3 in the 3D group; P = 0.623) and a smaller volume of additional margins excised at the index operation (19.52 cm^3 vs. 41.21 cm^3 in 3D group; P = 0.014). However, when total volume for the index operation (main specimen + additional margin) was calculated, no significant difference was found between the two groups (2D = 106.28 cm^3 vs. 3D = 115.62 cm^3; P = 0.562). When an additional surgery was performed, an average of 74.23 cm^3 of additional volume was removed in the 2D group compared with 25.42 cm^3 in the 3D group (P = 0.259). The total volumes of excision from index plus additional surgery were similar (P = 0.862).

Factors Associated with Re-excision for Positive Margins

Only 59 patients of the entire cohort had to undergo re-excision (50 in 2D vs. 9 in 3D; P = 0.014). Additionally, 19 (15%) of patients with DCIS and 27 (6%) of patients with invasive ductal carcinoma on final pathology underwent re-excision (P = 0.001). Of patients who had multifocal/multicentric disease, 17 (18%) underwent re-excision versus 42 (7%) of those without it (P = 0.001). On multivariable analyses, invasive ductal carcinoma (odds ratio [OR] = 0.354, 95% confidence interval [CI] 0.187–0.673, P = 0.002) compared with DCIS, and the use of 3D imaging compared with 2D (OR = 0.408, 95% CI 0.193–0.861, P = 0.019) remained independently associated with decreased re-excision rates. The presence of multifocal/multicentric disease was associated with an increased need for re-excision (OR = 2.75, 95% CI 1.436–5.249, P = 0.002; Table 3).

Comparison of 3D Versus 2D Re-excision Rate by Surgeon Using Both Techniques

During the study period, only one surgeon used 3D, employing it in 191 cases versus 143 cases using 2D (Table 4). There were no significant differences in patient, tumor, and surgical characteristics between both groups for this surgeon (data not shown). In the surgeon's 3D group, more patients had a mammographic finding of an asymmetry versus a mass with calcifications seen in the 2D group (P = 0.037) and were more likely to have oncoplastic surgery (P = 0.002). When using 2D, this surgeon performed less image-guided cavity excision (39% vs. 58% when using 3D), and although not significant, excised smaller main specimens and total specimen volumes. The surgeon's re-excision rate decreased from 9% to 5% with

TABLE 3 Factors associated with re-excision in both groups, with multivariable analyses

	OR	95% CI	*P* value
3D imaging versus 2D imaging	0.408	0.193–0.861	0.019
Multifocal versus unifocal disease	2.75	1.436–5.249	0.002
Final pathology versus DCIS			
IDCA	0.354	0.187–0.673	0.002
ILCA	1.25	0.493–3.187	0.635
Other*	0.486	0.152–1.1.559	0.225

OR odds ratio; *CI* confidence interval; *DCIS* ductal carcinoma in situ; *IDCA* invasive ductal carcinoma; *ILCA* invasive lobular carcinoma

*Other: includes invasive mucinous, papillary, mammary, and adenoid cystic carcinomas

TABLE 4 Subanalysis of main 3D surgeon, comparing her 3D and 2D cases

	2D group Total = 143 *n* (%)	3D group Total = 191 *n* (%)	*P* value
Mammographic finding			0.037
Mass	78 (54)	101 (54)	
Focal asymmetry/density	24 (17)	46 (24)	
Calcifications	28 (20)	36 (19)	
Mass with calcifications	13 (9)	5 (3)	
Oncoplastic closure			0.002
Yes	15 (10)	45 (24)	
No	128 (90)	146 (76)	
Directed margin excision			0.001
Yes	56 (39)	110 (58)	
No	87 (61)	81 (42)	
Final margin positive			0.259
Yes	12 (8)	8 (4)	
No	127 (89)	176 (92)	
Close (pure DCIS < 2 mm from margin)	4 (3)	7 (4)	
Re-excision performed			0.110
Yes	13 (9)	9 (5)	
No	130 (91)	182 (95)	
Volume main specimen (cm^3), mean ± SD	69.80 ± 288.72	91.94 ± 88.14	< 0.318
Volume additional margins (cm^3), mean ± SD	22.20 ± 24.34	41.21 ± 108.51	0.204
Total volume at index operation (cm^3), mean ± SD	78.33 ± 289.16	115.62 ± 145.97	0.125
Volume of re-excision (cm^3), mean ± SD	62.20 ± 42.28	25.42 ± 13.70	0.085
Total volume index + re-excision (cm^3), mean ± SD	82.68 ± 289.24	116.29 ± 145.79	< 0.166

SD standard deviation

the use of 3D ($P = 0.110$). On multivariable analysis, the use of 3D trended toward decreased re-excisions; however, this association was not significant (OR = 0.552, 95% CI 0.216–1.407, $P = 0.213$). This surgeon's 2D re-excision rate is similar to the other surgeons who use 2D (range 9–16%); however, smaller volumes of excision and less image-guided excisions were performed when using 2D versus 3D (Table 5).

DISCUSSION

We found that reoperation rates in both cohorts are already low. The rate for 2D group was 11% compared with 5% in the 3D group. Margin status is one of the most important determinants of local recurrence following breast-conserving surgery (BCS).[11,24,25] Positive margins are managed with re-excision or mastectomy, depending on number of margins involved and amount of residual breast tissue.[25] Published re-excision rates after BCS range from 3 to 50%.[26,27] A population-based study showed that after "no tumor on ink" consensus guidelines, re-excision rates after breast conservation were 14% with a 4% conversion to mastectomy.[21], [28] The decision to perform a second operation for close margins is multifactorial, and it includes surgical characteristics (whether the margin was close posterior but pectoralis fascia had been removed, if oncoplastic techniques were performed), discussion at tumor board, if adjuvant radiation will be given, tumor characteristics, and patient's risk factors for reoperation. In the 2D group, five patients who had positive final margins did not undergo surgery (2 had significant medical comorbidities, 2 had posterior margins taken down to fascia and adjuvant radiation was planned, and 1 had minimally positive focal area of DCIS anterior). In the 3D group, all the patients with positive final margins underwent re-excision except one who declined further treatment.

Various intraoperative margin assessment tools are available to guide surgeons to excise additional margins at index operation, other than intraoperative pathologic assessment, which is time consuming and costly.[29,30] Use of intraoperative ultrasound has been shown to decrease positive margins for palpable tumors.[31–33] Cavity shave margins (resection of additional margin of tissue at each

TABLE 5 Subanalysis of 2D cases by each surgeon versus 3D cases

Surgeon	Cases	Directed margin excision *n* (%)	Final Margin Positive *n* (%)	Re-Excision *n* (%)	Volume main specimen (cm^3) mean ± SD	Volume additional margins (cm^3) mean ± SD	Size of Shave mean (cm^3)	Final Volume (includes re-excisions)
1	101	40 (40)	13 (13)	16 (16)	116.04±122.42	21.50 ± 24.37	15.79	142.25 ± 144.37
2	68	13 (19)	5 (7)	7 (10)	92.57 ± 76.06	17.87 ± 14.57	10.73	102.69 ± 83.83
3	154	39 (25)	16 (10)	14 (9)	118.89 ± 178.47	15.93 ± 18.99	5.81	127.88 ± 179.12
4	143	56 (39)	12 (8)	13 (9)	69.80 ± 288.72	22.20 ± 24.34	18.95	82.68 ± 289.24
4 (3D cases)	191	110 (58	8 (4)	9 (5)	91.94 ± 88.14	41.21 ± 108.51	25.06	116.29 ± 145.79

cavity wall) has been shown to have lower positive margin rate,[34–36] especially if the positive margin rate is higher than 25%.[30] Specimen radiographs also have been shown to decrease re-excisions,[16,37,38] especially 2D intraoperative specimen mammography.[17,18,39] In a single study of 93 patients, 2D decrease re excision rate from 12 to 5%.[17] Chagpar et al. determined that in 90 cases of BCS, 2D radiography decreased the positive margins from 38% to 30%, and if 3D was added, this reduced to 29%.[40] In our study, the surgeon who used 3D imaging had a reduction in re-excision rate from 9 to 5%. Other available modalities for margin assessment include microcomputed tomography, 18F-fluorodeoxyglucose specimen-positron emission mammography, intraoperative MRI, handheld optical imaging probe, and radiofrequency spectroscopy/MarginProbe.[41–47]

Factors associated with positive margins include younger age, DCIS, large tumor size, presence of lymphovascular invasion, multifocality, lobular histology, invasive ductal carcinoma with extensive intraductal component.[12,24], [48–51] Similarly, we found an association with re-excision in both groups if DCIS and multifocal/multicentric disease was present. The 2D group had a higher percentage of DCIS on preoperative core biopsies (26% vs. 19% in 3D group; P = 0.077). DCIS poses a challenge during breast conservation as true size may be underestimated by preoperative imaging.[52,53] Factors associated with residual disease for DCIS post BCT include large tumor size (DCIS $\geq$ 2.5 cm) and presence of positive margins.[54] The majority of DCIS does not form a mass, so surgeons must rely heavily on intraoperative specimen radiographs.[12] DCIS with calcifications near resection margins (< 1 cm) is associated with close or positive margins.[55] Also, the great majority of our patients underwent RS localization compared with WL. In the largest randomized trial, RSL and WL have similar rate of margin positivity; our numbers are too small to compare both approaches.[56]

The goal of breast conservation is to achieve survival and locoregional recurrence rates similar to mastectomy while maintaining cosmesis. The volume of excision impacts cosmetic outcome.[57] Studies have shown that intraoperative specimen radiography can reduce specimen weights without increasing re-excision rates.[38,57] In our study, we found similar volumes of excision among both groups. The 3D group, which had higher percentage of directed margin excision at index operation, removed slightly greater volume than the 2D group. However, in the 2D group, a return for reoperation resulted in higher volumes in re-excised specimens. In the end, both groups have equivalent volumes excised (mean 113.45 cm^3 in 2D group vs. 116.29 cm^3 in 3D group; P = 0.862).

Some of the limitations of this study include its retrospective nature and short time interval without an analysis of the locoregional recurrence rate. To mitigate the surgeon selection bias, because the 3D cases were performed by one surgeon, a subanalysis was performed to review that surgeon's prior cases using 2D. On multivariable analysis, the use of 3D versus 2D did not remain significantly associated with a decreased re-excision rate. The re-excision rate with 2D was 9%, similar to the main cohort of 2D, and with the addition of 3D tomosynthesis, dropped to 5%. This lends credence to the association of 3D with decreased re-excision rates. It is worth noting that this surgeon took more margins with 3D and smaller volumes of excision at index operation with 2D, which increased with the use of 3D tomosynthesis. 2D-guided excision had a higher correlation between additional margins and positive/close margins in main specimen (30% vs. 17% in 3D-guided). However, the use of 3D tomosynthesis increased the number of margins excised and identified additional disease that would have otherwise had negative margins.

CONCLUSIONS

The use of 3D tomosynthesis specimen radiographs decreased re-excision rates by more than half. This study demonstrated that surgeons can use these techniques without radiologists' interpretation to achieve excellent re-excisions rates. The use of 3D tomosynthesis may be considered to reduce reoperation rates by allowing surgeons to excise additional directed margins at index operation.

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