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REVIEW

Awareness of residents' technical ability can affect margin status in breast conserving operations

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Abstract

Purpose The current study was performed to determine if awareness of the potential affect of residents could affect margin status.

Methods Retrospective review of all patients who underwent lumpectomy from July 2006 to May 2017 was evaluated. The effect of surgical residents' participation and their technical ability was evaluated to determine the effect on margin status. Logistic regression analysis was performed to determined factors which affect margin status.

Results Of 444 patients, 14% of patients had positive margins. The positive margin rate was lower during the second time period after the effect of technical ability of the residents was known 12% versus 19% ($p=0.10$). Greater participation by the attending surgeon (32% vs. 21%) occurred in the second time period. In multivariate logistic regression analysis, operations done by residents with satisfactory technical skills or attending surgeon were less likely to have positive margins than those done by residents with unsatisfactory technical skills (OR 0.19, 95% CI 0.10–0.38; $p=0.0001$). With mean follow-up of 48 months, 1.4% had local recurrences as a first event.

Conclusions Technically ability of residents appears to affect margin status after lumpectomy. Increased intervention by the attending surgeon can improve this outcome.

Keywords Lumpectomy · Breast conservation · Margin · Teaching · Technical ability

Introduction

Breast conservation surgery has been the recommended and most common operation for early stage breast cancer for many years [1]. With appropriate systemic therapy, risk for local recurrence after lumpectomy with radiation is 5.3% [2]. Many variables affect risk for local recurrence; however, the two most important factors are completing postoperative radiation therapy and margin status [3].

For years margin status and the appropriate "distance" of an appropriate margin was debated and controversial [4, 5]. In 2014, however, the Society of Surgical Oncology-American Society for Radiation Oncology published a consensus statement based on the available data which resulted in significant clarity to the question of the distance of an appropriate margin [2].

Attainment of negative margins remains a difficult process as a 2015 study in the New England Journal of Medicine still reported that more than one of three (35%) of breast conservation operations result in positive margins [6]. Other studies have found re-excision rates over 50% and up to 69% [7, 8]. Positive margins are problematic for several reasons. If no further operation is performed, positive margins are a significant predictor of risk for local recurrence [3]. Re-excision results in increased tissue removal and worse cosmetic outcome [9, 10]. After one failed attempt at lumpectomy, a proportion of women will opt for mastectomy and therefore the goal of breast conservation is lost. In addition, the subsequent operations required for positive margins also

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greatly increase health care costs [11]. The cost of operations becomes of greater importance in an uninsured population, where each operation must be paid out of pocket. Patient expenses have become relevant even in insured patients with the changes to the current plans requiring greater patient responsibility.

Therefore, study of factors which affect positive margins are important. One factor which appears to lower rates of positive margins is intraoperative analysis of margins [12]. By any technique, however, intraoperative analysis requires significant pathologic manpower and the majority of data comes from large tertiary referral centers [12, 13]. Due to this limitation, it is not feasible and not utilized at most institutions [14]. Another factors that have been examined include the use of shave margins and use of an intraoperative margin probe [6, 15, 16].

While some studies have examined the effect of experience of the operating surgeon, few studies have examined the effect of teaching residents on margin status [17–19]. We previously examined our initial experience and it did appear that the technical ability of the resident affected margin status [20]. As a result of the initial findings, the current study was performed to evaluate if margin status could be improved during the teaching of residents if we were mindful this potential effect on margin status.

Methods

A retrospective review was performed of all patients who underwent a breast conserving operation at Maricopa Medical Center for a primary breast cancer from July 1, 2006 to June 30, 2017. Institutional review board approval was obtained for the study (#2010-048). All patients with a previous history of breast cancer who developed a new primary or recurrence were excluded from the study. There was one attending surgeon (IKK) of record for all patients during the study period. There were two time periods in this study. Time period 1 included the original data set on 106 patients until 2009 [20]. Time period 2 includes the subsequent 338 patients after the results of the first study were known.

Maricopa Medical Center has a fully accredited 5-year surgical residency program approved for four chief residents per year [20]. The content of the residency program includes rotations in trauma and acute care surgery, critical care, burn surgery, pediatric surgery, head and neck surgery, urology, plastic and reconstructive surgery, hand surgery, transplant surgery, vascular surgery, neurosurgery, minimally invasive surgery, hepato-biliary surgery, thoracic surgery, and general surgery. Second year residents rotated on the breast service where all cases were considered teaching cases and the resident was usually considered the primary surgeon. If the assigned resident was on vacation, unavailable for the case, or the resident was unprepared to operate, then the attending surgeon was considered the primary surgeon.

Technical ability of each resident was evaluated by the attending surgeon (IKK). There is only one attending surgeon who performs breast operations at this institution. The technical ability of the resident was only evaluated with respect to breast operations and was subjectively graded by the attending surgeon in binomial fashion: satisfactory or unsatisfactory in comparison with other residents at the same level of training (Described previously [20]). This evaluation of technical ability was not meant to be an evaluation of overall technical skills, i.e., the ability to perform breast cancer operations may not have correlation with laparoscopic technical ability. Factors which caused residents to be given the evaluation of unsatisfactory technical skills, were inability to stay in one plane of dissection (creating multiple planes of dissection), inability to avoid cutting into the desired specimen, and rough handling of the tissues.

Because of the awareness of the results of the previous study (time period 1) [20], two changes were made in time period 2. First all residents were required to watch ("see one") the first lumpectomy case before they were allowed to perform ("do one") their first lumpectomy. Second, the attending surgeon was very concerned when a resident demonstrated unsatisfactory technical skills. After those residents "saw one," if they showed the inability to stay in one plane of dissection during their first attempt, the attending surgeon again performed the case so that the resident could again "see [another] one." This was continued until the resident demonstrated the ability to meet minimal expectations of the attending surgeon.

Data collection for the current study regarding margin status after lumpectomy was not started until after the last rotation included in the study. Therefore at the time of completing the rotation evaluations for the residents studied, no knowledge of the effect on margin status of each resident was known. Sociodemographic information, clinical characteristics, and surgical outcomes for all patients were collected. Patients were followed as long as they continued to return to the medical center for follow-up. Sites of first events and cause of deaths were recorded.

Surgical technique and pathologic evaluation

Details about surgical technique and pathologic evaluation at the institution studied were described previously [20]. Circumferential shaved margins as described by Chagpar et al. were not performed at our institution. Similar to the description of the "standard partial mastectomy" in the Chagpar et al. publication, the additional resection of margins was performed at the discretion of the attending

surgeon based on assessment of the specimen (where the tumor was believed to possibly be close to the edge of the specimen) or based on standard specimen radiograph (or both). This was normally one additional margin (i.e., only the inferior margin or only the medial margin, rather than the entire circumferential margin) [6]. This occurred in 42% (54/130) of cases done by the attending surgeon, 54% (115/212) of cases done by residents with satisfactory skills, and 62% (63/102) of cases done by residents with unsatisfactory skills. The volume of breast tissue removed was determined by the product of the anterior–posterior, medial–lateral, and inferior-superior diameters listed on the pathology report. When microscopic examination revealed tumor (invasive or non-invasive) touching an inked surface, this was considered "positive" or transected margin. A margin was considered "close" when microscopic evaluation demonstrated the tumor edge within 1 mm of an inked surface. The pathologic definition of "positive" and "close" margins did not change over the time period studied. Re-excision lumpectomy was recommended for any patient with a close or positive margin until 2014. After the publication of the ASCO-ASTRO consensus guidelines, re-excision was not required for close margins [2]. Due to the publication of the ASCO-ASTRO consensus guidelines and the resulting change in clinical practice during the time period studied, margin status was used as the primary outcome rather than re-excision rate. This was done because re-excision rate likely would have decreased overall due to publication of the guidelines; however, pathologic assessment of margin status did not change.

Statistical considerations

Margin status and volume of tissue removed were evaluated in the study population. The overall positive margin rate was then evaluated by time period. Outcomes were then stratified based on the presence of a resident and then on the technical ability of the resident. The number of cases done by each individual resident was too small and could not be examined separately as an effect on margin status. For categorical variables Fisher's exact test was used to determine differences between the two populations. Unpaired (two-sample) *t* test was used to compare means of the two populations. Univariate and multivariate logistic regression analyses were performed to evaluate the effect of variables previously reported to affect margin status, i.e., patient age, clinical tumor size, palpable tumors, ductal carcinoma in situ (DCIS) histology, and presence of extensive intraductal component (EIC) and lymphovascular invasion (LVI), on margin status for this study. All statistical tests were two-sided and $p = 0.05$ was considered statistically significant.

Results

Over the time period evaluated, 444 patients had a breast conserving operation. Table 1 shows the patient characteristics, with the mean age was 52 years and most patients were Hispanic and either uninsured or insured by AHCCCS (Medicaid).

Most patients presented with clinical T2 tumors, palpable masses, and at clinical stage II (Table 2). The rate of breast conservation during time period 1 was 62% (106/172) and time period 2 was 68% (338/496). The overall rate of positive or close margins was 14% (Table 3). The rate of positive margins improved from 19% in the time period 1 to 12% in the follow-up time period 2 ($p = 0.10$; Table 3). When the technically ability of the resident was considered, significant differences were identified. Residents with unsatisfactory technical skills had a rate of close or positive margins of 30% (Table 3). This was significantly higher than residents with satisfactory technical skills (9% vs. 30%, $p = 0.0001$). The rate of positive margins were nearly identical for residents with satisfactory technical skills and the attending surgeon (8% vs. 9%, $p = 0.85$).

The difference in margin rate between residents with differing technical skill could not be attributed to lumpectomy volume. Despite having the highest positive margin rate, technically unsatisfactory residents also had the largest lumpectomy volumes of the three groups (Table 3). The re-excision lumpectomy operations performed by the attending surgeon showed residual cancer in 2 of 11 (18%) specimens, by satisfactory residents 10 of 20 (50%) specimens, and by unsatisfactory residents in 15 of 29 (52%) specimens.

Univariate and multivariate logistic regression analyses were then performed to evaluate variables commonly thought to affect margin status. After adjustment for patient age, clinical size, DCIS histology, and presence of LVI and EIC, technically ability of the surgical resident remained significantly associated with margin status (Table 4). Operations done by a resident with satisfactory technical skills or the attending surgeon had a lower risk for positive margins than compared to operations done by residents with unsatisfactory skills (OR 0.19, 95% CI 0.10–.038; $p = 0.0001$). Factors well known to increased risk for positive margins, extensive intraductal component (EIC) and lymphovascular invasion (LVI), were also found to be associated with increased risk for positive margins (OR 6.7, $p = 0.0001$ and OR 2.9, $p = 0.01$, respectively).

The overall improvement in margin status did come at the expense of resident experience, however, as a greater

Table 1 Sociodemographics of all patients and by time period

	Time period 1 2006–2009 ($N=106$)	Time period 2 2010–2017 ($N=338$)	*P* value*
Age: mean (SD)	51.4 (10.9)	52.2 (10.5)	0.47
Mean weight	77.8 (18.7)	78.9 (20.2)	0.61
Mean BMI	31.4 (7.02)	29.8 (10.2)	0.13
Ethnicity			
Non-Hispanic White	16 (15%)	70 (21%)	
African American	9 (8%)	30 (9%)	
Hispanic	75 (71%)	205 (61%)	0.07
Other	6 (6%)	33 (9%)	
Education (years)			0.03
13+	23 (22%)	96 (28%)	
12	25 (24%)	82 (24%)	
9–11	6 (6%)	52 (15%)	
0–8	46 (43%)	98 (29%)	
Unknown	6 (6%)	0	
Employment			
Employed	41 (39%)	108 (32%)	0.24
Unemployed	50 (47%)	185 (55%)	
Retired/disabled	15 (14%)	45 (13%)	
Monthly household income, dollars (SD)	983.94 (890.28)	1117.49 (1132)	0.27
Insurance			
Commercial	2 (2%)	10 (3%)	
Medicare	6 (6%)	13 (4%)	
Medicaid	35 (33%)	97 (29%)	
None	63 (59%)	218 (64%)	0.36
Screening			
Mammogram in 2 years prior to diagnosis (age 40+)	34/91 (37%)	61/302 (20%)	0.001

SD standard deviation

*Derived from a Fisher's exact test for categorical variables and a two-sample *t* test for continuous variables

proportion of the cases were performed by the attending surgeon in time period 2 compared to time period 1 (32% vs. 21%).

Breast cancer specific survival was 95%. The overall rate of radiation therapy was 93% (414/444). The overall rate of adherence to chemotherapy was 92% (217/236) and endocrine therapy was 89% (297/329). Of 360 patients with at least 2 years of follow-up (mean follow up of 59.8 months), five patients (1.4%) had an ipsilateral breast tumor recurrence as their first event during the study period.

Discussion

The overall positive margin rate (14%) on the group of patients studied was at the low end of the expected range (14–69%) compared to previously published data [6, 8, 12, 14, 21–25]. Technical skill of residents continued to be associated with risk of positive margins. Awareness of the effect did allow for improvements to be made such that the rate of positive margins decreased in time period 2 compared to the initial time period 1 (12% vs. 19%). This improvement, however, did result in greater intervention by the attending surgeon and overall fewer cases performed by residents. The decline in the rate of positive margins cannot be attributed to more selective use of breast conserving operations as the proportion of patients undergoing breast conservation increased in time period 2 (68% vs. 62%, $p=0.13$).

Three previous studies examined the effect of resident participation on breast cancer operations. Two studies found no difference. Aguilar et al. found similar re-excision rates in operations done by attending surgeon with or without resident assistance [18]. This study was done, however, at an institution where intraoperative analysis of margins were performed for all cases and this may have blunted any effect of resident participation. A study by

Table 2 Clinical characteristics and histopathologic variables

	All patients ($N=444$)	Time period 1 ($N=106$)	Time period 2 ($N=338$)	P value*
Clinical tumor size				0.07
T1	206 (46%)	41 (39%)	165 (48%)	
T2	163 (37%)	46 (43%)	117 (35%)	
T3	75 (17%)	19 (18%)	56 (17%)	
Palpable mass	261 (59%)	72 (68%)	189 (56%)	0.03
Clinical stage				0.10
0	90 (20%)	18 (17%)	72 (21%)	
I	122 (27%)	25 (24%)	97 (29%)	
II	211 (48%)	57 (54%)	154 (46%)	
III	21 (5%)	6 (6%)	15 (4%)	
Predominant histology				0.18
Ductal	389 (88%)	97 (92%)	292 (86%)	
Lobular	26 (6%)	5 (5%)	21 (6%)	
Other	29 (6%)	4 (4%)	25 (8%)	
Histologic grade				
Well	89 (20%)	16 (16%)	73 (22%)	
Moderate	181 (41%)	38 (38%)	143 (42%)	
Poor	169 (39%)	47 (47%)	122 (36%)	0.06
Hormone receptor				0.25
Positive	322 (77%)	60 (72%)	266 (78%)	
Negative	95 (23%)	23 (28%)	72 (22%)	
Her 2 neu (IHC 3+ or FISH+)	51/350 (14%)	17/88 (19%)	34/262 (13%)	0.16

IHC immunohistochemistry

*Derived from a Fisher's exact test for categorical variables and a two-sample t test for continuous variables

Table 3 Outcomes of breast conserving operations

	All patients ($N=444$)	Time period 1 ($N=106$)	Time period 2 ($N=338$)	Specimen volume (cm^3)
Lumpectomy margins				
Positive/close (< 1 mm)	62/444 (14%)	20/106 (19%)	42/338 (12%)	214.9
Resident unsatisfactory	31/102 (30%)	12/35 (34%)	19/67 (28%)	228.1
Resident satisfactory	20/212 (9%)	4/48 (8%)	16/164 (9%)	213.6
Attending surgeon	11/130 (8%)	4/23 (17%)	7/107 (7%)	206.4

Margin status and volume of lumpectomy specimen by operating surgeon

Tsigonis et al. also did not find a difference in re-excision rates based on resident participation, 22% versus 28% [19]. The third study by Cleffken et al. [17] examined resident participation as well as level of training, junior (PGY1-3) residents (JR) and senior (PGY4-6) residents (SR). They found no difference in rates of involved margins in breast conserving operations for palpable cancers between the three groups. In non-palpable cancers, however, operations done by JR had a higher rate of involved margins compared to the other two groups (39% vs. SR: 14% and attending surgeon: 17%). In the current study, the differences in rates of involved margins were similar to those seen in above study (unsatisfactory: 30% vs. satisfactory: 9% and AS: 8%). Therefore, the residents in the current study with high rates of involved margins may in fact not have "unsatisfactory" technical skills, but possibly have just not yet made the transition to the senior resident technical ability. Many surgical educators feel that the transition to senior level technical ability occurs in the PGY4 year. By contrast, American College of Surgeons National Surgical Quality Improvement Program Participant Use File demonstrated that most breast cancer cases are done by junior residents

Table 4 Factors associated with positive margins after lumpectomy

Variable	Univariate analysis		Multivariate analysis[b]	
	OR	*P* (95% CI)	OR	*P* (95% CI)
Age	1.00	0.69 (0.97, 1.02)	1.02	0.37 (0.98, 1.05)
BMI (kg/m^2)	0.98	0.43 (0.94, 1.03)	0.99	0.73 (0.94, 1.04)
Palpable mass	1.12	0.70 (0.64, 1.93)	0.88	0.74 (0.43, 1.82)
Tumor size	1.00	0.63 (0.99, 1.02)	1.01	0.38 (0.99, 1.03)
Volume of excision	0.999	0.38 (0.997, 1.001)	0.998	0.11 (0.996, 1.000)
Histology (DCIS vs. others)	1.18	0.61 (0.63, 2.18)	2.20	0.12 (0.83, 5.78)
EIC	6.26	< 0.0001 (3.26, 12.02)	6.71	< 0.0001 (3.11, 13.52)
LVI	2.59	< 0.01 (1.31, 5.14)	2.85	< 0.01 (1.34, 6.40)
Primary surgeon[a]	0.23	< 0.0001 (0.13, 0.40)	0.19	< 0.0001 (0.10, 0.37)

[a]Primary surgeon (resident with satisfactory technical skills and attending surgeon compared to resident with unsatisfactory technical skills)

[b]Adjusted for EIC (extensive intraductal component (DCIS > 25% of tumor), LVI (lymphovascular invasion), palpable mass, and primary surgeon

[26]. Similarly, in the current study nearly all cases were done by PGY2 residents.

The Cleffken study as well as another study by Moorthy et al. also described the potential difficult with the impalpable cancer, such as the ability to make a three dimensional mental image of the operating field [17, 27]. It did appear that the residents who did have technical ability to meet expectations appeared to have the ability prior to starting the rotation or were able to immediately assimilate the ability after "seeing one." By contrast in the current study, despite constant feedback during the cases, for those who did not have the technical ability to create and maintain the proper plane of dissection, none of them were unable to acquire the skills in a 2-month period.

Residents with unsatisfactory technical skills were more likely to be rough when handling tissue and unable to stay in one plane of dissection through the breast tissue. These deficiencies could contribute to additional exposed surface area of tumor, with increased likelihood of contact with ink from the pathologist, resulting in a positive margin. The finding that residents with unsatisfactory technical skills have positive margin rates of 30% versus 9%, despite residual cancer being found in subsequent re-excision specimens at a similar rate (52% vs. 50%), may support this concept that they were rough with tissue, create unnecessary planes, and increased exposed surface area resulting in the positive margin. Nonetheless, these positive margins resulted in an additional operation for the patient.

It is possible, however, that residents develop the skill later in residency. An example was one resident received an unsatisfactory technical evaluation as a PGY2. The resident later needed additional breast cases due to recent changes in the ACGME requirements. The resident then performed cases as a PGY4 and did demonstrate the expected satisfactory technical skills. This anecdote does support the hypothesis by Cleffken et al. that some residents acquire skills later in training and that there is a learning curve with operative experience [17, 28]. This finding that the resident was able to demonstrate the skills as a PGY4 without additional specific breast technical training supports the idea that needed operative skills and experience can be gained through general overall surgical experience.

In clinical practice, patients and surgical residents cannot be selected or "randomized" to a particular group. As at most institutions, cases are performed chronologically and based on urgency of the disease process. In the current study, there was no selection of residents for operations and case assignments were done based on the resident schedule set at the start of the academic year. A multivariate analysis was performed to correct for any unexpected or unavoidable biases that may have occurred using common factors known to affect margin status (Table 4). The technical ability of the resident remained a statistically significant predictor of positive margins (Satisfactory technical ability OR 0.19; 95% CI 0.10–0.38, $p = 0.0001$).

There were limitations associated with our current study. First, the study was performed at a single community based safety net institution. This data was collected at a single institution and evaluation of technical ability was subjectively obtained by a single surgeon. While this aspect reduced variability, it may have led to some element of bias. Objective methods of evaluation of residents in the current world of surgical training are not widespread and in the operating room observations of surgeon technique are under-reported. Further, while simulators do exist for minimally invasive and robotic training, objective evaluations of technical ability for breast operations do not exist. The technical skills in breast surgery are completely different than those used in laparoscopy and therefore some may assume that the findings here cannot be equally applied in

other areas of surgery. Recently, there have been reports of video evaluation of surgeon technical skill in more complicated surgical procedures. Studies by Hogg et al. and Birkmeyer et al. found that technical performance affected outcomes such as postoperative fistula rate in pancreaticoduodenectomy and reoperation rates and mortality in laparoscopic gastric bypass, respectively [29, 30]. The use of video evaluation as a form of postoperative review or "film study" may provide an additional methodology to teach residents and review the expected technique for a particular operation [31]. It could also repeat and reinforce the teaching that occurred in the operating room. Further, the lower pressure environment of watching the technique outside the operating room could possibly provide a different perspective which could assist in the learning process for certain residents [32]. The importance of intra-operative observation and direct surgeon-surgeon mentorship and its increased use appears to be of expanding importance in other fields of surgery.

No remediation of technical skills was used during the study period. No remediation was performed due to the thought that a breast model/simulator was not available at our program. As mentioned above, however, it may be that general overall operative experience can improve skills specific to breast cancer operations, even without a known breast model/simulator. This concept will be incorporated into our residency program going forward, i.e., requiring PGY2 residents with unsatisfactory technical skills to log increased time with their technical skills devices. A third limitation was that the study took place at a safety net institution and therefore the poor use of screening and delays in presentation of patients may not be applicable to other patient populations. Fourth, breast MRI and other modalities were not used in the preoperative evaluation for surgical margins in the current study. Therefore, the results described may be different and not apply at institutions where other modalities are available and utilized [33].

The current study found that breast-conserving operations performed by residents with satisfactory technical skills had a statistically significant lower rate of positive margins compared to residents with unsatisfactory skills. The findings of the previous similarly conducted study were reinforced by the findings of the current study with an increase in number of operations and residents over a longer period of time. Increased intervention by the attending surgeon can improve this outcome; however, this increased intervention did come at the cost of decreased resident participation. The lower rate of positive margins achieved did result in fewer reoperations for the patients.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval This retrospective study was approved by the Institutional Review Board.

Research involving human and animal participants This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Not applicable as this was a retrospective study.

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