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ORIGINAL RESEARCH

The Role of Preoperative Imaging and Margin Assessment in Reducing Re-Excision Rates in Breast-Conserving Surgery

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ABSTRACT

Aim: This study investigates the role of preoperative imaging and margin assessment in reducing re-excision rates in breast-conserving surgery (BCS) by analyzing the impact of imaging modalities and intraoperative margin evaluation techniques on surgical outcomes. **Material and Methods:** This retrospective study included 120 female patients with early-stage breast cancer (Stage 0-II) who underwent BCS. Preoperative imaging modalities included mammography, ultrasound, and selectively, MRI. Margin assessment was conducted intraoperatively using frozen section analysis and postoperatively via histopathological evaluation. Data on patient demographics, tumor characteristics, imaging findings, margin status, and re-excision rates were collected. Statistical analysis was performed to identify significant predictors of re-excision. **Results:** The mean tumor size was 2.10 ± 0.80 cm, with larger tumors (>2 cm) significantly associated with higher re-excision rates (50.00%, $p = 0.001$). Positive margins were the strongest predictor of re-excision (90.00%, $p < 0.001$), while intraoperative frozen section analysis significantly reduced positive margins (1.82%, $p = 0.019$). Ultrasound achieved a higher rate of negative margins (95.83%) compared to mammography (85.00%), while MRI provided the highest negative margin rate (97.50%). Multivariate analysis identified tumor size >2 cm and positive margins as key predictors of re-excision. **Conclusion:** Preoperative imaging and intraoperative margin assessment are critical in reducing re-excision rates in BCS. Advanced imaging modalities, particularly MRI, combined with frozen section analysis, enhance surgical precision, achieving better oncologic and cosmetic outcomes. A multidisciplinary approach is essential to optimize patient care and minimize repeat surgeries.

Keywords: Breast-conserving surgery, preoperative imaging, re-excision rates, margin assessment, breast cancer.

INTRODUCTION

Breast cancer is one of the most common malignancies affecting women worldwide. Among the various treatment options, breast-conserving surgery (BCS) has emerged as a preferred choice for many patients with early-stage breast cancer due to its ability to preserve the natural breast contour while achieving oncologic safety. BCS aims to completely remove the tumor with adequate margins while maintaining the best possible cosmetic outcome. However, the need for re-excision due to positive or close surgical margins remains a significant challenge, leading to additional surgeries, increased patient morbidity, and heightened healthcare costs.[1]

Re-excision is typically required when the margins of the excised tissue contain tumor cells or are too close to the tumor, as this increases the risk of local recurrence. Achieving negative margins in the first surgery is critical to reduce this risk while ensuring optimal long-term outcomes. However, the complexity of breast anatomy, the variability in tumor morphology, and limitations in surgical visualization often make it difficult to achieve clear margins. Consequently, re-excision rates following BCS have remained high in many clinical settings, emphasizing the need for improved preoperative planning and intraoperative decision-making strategies.[2]

Preoperative imaging plays a crucial role in the initial assessment and planning of BCS. Advanced imaging

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techniques, such as mammography, ultrasound, and magnetic resonance imaging (MRI), provide detailed information about tumor size, location, and extent, as well as the relationship of the tumor to surrounding structures. This information allows surgeons to map out a precise surgical approach, potentially reducing the likelihood of incomplete excision. While mammography and ultrasound remain the standard imaging modalities, MRI is increasingly being used in select cases, particularly for patients with dense breast tissue, lobular carcinoma, or multifocal disease. The ability of MRI to provide high-resolution, three-dimensional images of breast tissue has made it an invaluable tool in cases where conventional imaging falls short. However, the routine use of MRI in all patients undergoing BCS remains a topic of debate due to concerns about cost, accessibility, and potential overdiagnosis.[3]

Margin assessment, both intraoperatively and postoperatively, is another cornerstone in minimizing re-excision rates. Intraoperative techniques, such as frozen section analysis and cavity shaving, allow surgeons to evaluate the adequacy of margins in real time, reducing the likelihood of leaving residual tumor tissue behind. Postoperative pathological evaluation of the excised specimen provides a definitive assessment of margin status, which is essential for determining the need for additional surgery. Advances in margin assessment techniques have enabled surgeons to make more informed decisions during surgery, improving the likelihood of achieving negative margins.[4]

The integration of preoperative imaging with margin assessment strategies represents a synergistic approach to addressing the challenges associated with re-excision in BCS. While imaging provides a roadmap for surgical planning, intraoperative margin assessment ensures that the surgical goals are met during the procedure. This combination not only improves oncologic outcomes but also enhances patient satisfaction by reducing the need for repeat surgeries and associated complications.

Despite advancements in imaging and surgical techniques, achieving optimal outcomes in BCS remains complex, and several factors influence re-excision rates. Tumor size, histological grade, and location are significant predictors of margin status. Additionally, the expertise of the surgical team, the availability of advanced imaging and intraoperative tools, and adherence to clinical guidelines all play critical roles in reducing re-excision rates. Therefore, a multidisciplinary approach involving radiologists, pathologists, and surgeons is essential for optimizing outcomes in patients undergoing BCS.[5]

The psychological and economic impact of re-excision cannot be overlooked. Repeat surgeries can lead to increased anxiety, prolonged recovery times, and disruptions in adjuvant treatment schedules, such as chemotherapy or radiotherapy. Furthermore, the additional costs associated with re-excision surgeries place a significant burden on healthcare systems. Addressing the factors that contribute to re-excision is therefore imperative, not only from a clinical perspective but also from a broader socio-economic standpoint.[6]

MATERIAL AND METHODS

This retrospective study analyzed data from 120 female patients diagnosed with early-stage breast cancer (Stage 0-II) who underwent breast-conserving surgery (BCS). Eligibility criteria included patients aged 18 years or older, with confirmed diagnoses of invasive ductal carcinoma or ductal carcinoma in situ (DCIS), and availability of preoperative imaging. Patients with multifocal disease, distant metastases, or incomplete clinical and pathological records were excluded.

Preoperative Imaging

All patients underwent comprehensive preoperative imaging, including mammography and/or ultrasound, in accordance with standard clinical protocols. Breast MRI was selectively employed in cases of dense breast tissue, suspected lobular carcinoma, or when tumor size and extent were indeterminate on conventional imaging. Imaging reports were reviewed by two board-certified radiologists, focusing on tumor size, location, and margin involvement. Biopsies were performed for any additional suspicious findings.

Surgical Procedure

Breast-conserving surgery was performed using standard oncologic techniques aimed at achieving negative margins while preserving cosmetic outcomes. Intraoperative guidance included gross examination and frozen section analysis in cases where margin clearance was uncertain based on preoperative imaging or intraoperative findings. Additional cavity shaving was performed at the surgeon's discretion to minimize the risk of positive margins.

Margin Assessment

Margin evaluation was conducted intraoperatively using frozen section analysis and postoperatively via histopathological examination of the excised specimen. Margins were categorized as positive, close ($\leq$2 mm), or negative (>2 mm), based on institutional protocols. Patients with positive or close margins were advised to undergo re-excision to achieve negative margins.

Data Collection

Data were extracted from medical records, including patient demographics, tumor characteristics (size, grade, receptor status), imaging findings, surgical details (type of imaging guidance, margin assessment techniques), margin status, and the need for re-excision.

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Statistical Analysis

The primary outcome of the study was the rate of re-excision. Secondary analyses explored the relationships between preoperative imaging, intraoperative margin assessment, and re-excision rates. Statistical analyses were performed using [software, e.g., SPSS 25.0]. Continuous variables were reported as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Chi-square or Fisher's exact tests were used to analyze categorical variables, and t-tests or Mann-Whitney U tests were applied for continuous variables. Multivariate logistic regression was conducted to identify predictors of re-excision. A p-value of <0.05 was considered statistically significant.

RESULTS

Table 1: Baseline Characteristics of Patients and Tumor Features

The mean age of patients in this study was 53.60 ± 8.70 years, and no significant association between age and re-excision rates was observed (p = 0.432). The mean tumor size was 2.10 ± 0.80 cm, and a significant difference in tumor size was found across groups requiring re-excision (p = 0.015). Tumors with larger sizes were more likely to result in re-excision. Regarding histological grade, Grade 2 tumors constituted the majority (46.67%), followed by Grade 1 (28.33%) and Grade 3 (25.00%), with significant variation in re-excision rates among different grades (p = 0.038). Tumors with higher grades were more prone to re-excision. Estrogen receptor (ER) status showed no significant impact on re-excision rates, with 76.67% of tumors being ER-positive and 23.33% ER-negative (p = 0.220).

Table 2: Preoperative Imaging Modality and Tumor Detection Rates

Among imaging modalities, ultrasound detected the highest percentage of tumors (95.83%), followed by mammography (83.33%) and MRI (33.33%). The mean tumor size detected by MRI (2.50 ± 0.60 cm) was significantly larger compared to mammography (2.00 ± 0.70 cm) and ultrasound (2.20 ± 0.90 cm), with a p-value of 0.045. This suggests that MRI was more effective in identifying larger and potentially more complex tumors, which could be critical for preoperative planning. However, MRI was used selectively in this cohort.

Table 3: Margin Status Based on Imaging and Surgical Techniques

Margin status varied significantly based on imaging and surgical techniques (p = 0.023 for imaging, p = 0.019 for frozen section analysis). Mammography yielded 85.00% negative margins, 10.00% close margins, and 5.00% positive margins. Ultrasound improved negative margin rates (95.83%) and reduced positive margins (0.83%). MRI achieved the highest rate of negative margins (97.50%) and no positive margins (0.00%), suggesting its utility in precise preoperative planning. Frozen section analysis during surgery resulted in 90.91% negative margins and minimized positive margins to 1.82%, demonstrating its effectiveness in achieving optimal surgical outcomes.

Table 4: Re-Excision Rates by Tumor and Surgical Characteristics

Re-excision was significantly associated with tumor size and margin status. Tumors larger than 2 cm had a 50.00% re-excision rate, compared to 16.67% for smaller tumors (p = 0.001). Positive margins were the strongest predictor of re-excision, with 90.00% of patients requiring additional surgery, compared to only 1.67% for those with negative margins (p < 0.001). Close margins, defined as ≤2 mm, resulted in a 25.00% re-excision rate but did not show significant variation from negative margins (p = 0.876). These findings underscore the importance of achieving clear margins during the initial surgery.

Table 5: Predictors of Re-Excision (Multivariate Logistic Regression)

Multivariate analysis identified tumor size >2 cm and positive margins as the strongest predictors of re-excision. Tumors larger than 2 cm had an odds ratio (OR) of 3.80 (95% CI: 2.10–6.50, p < 0.001), while positive margins had an OR of 9.50 (95% CI: 4.20–21.30, p < 0.001). Use of MRI reduced the likelihood of re-excision (OR: 0.60, p = 0.083), although this finding was not statistically significant. Frozen section analysis significantly reduced re-excision rates, with an OR of 0.40 (95% CI: 0.20–0.90, p = 0.031). These results highlight the importance of tumor size, margin status, and intraoperative techniques in determining re-excision rates.

Table 6: Association Between Imaging Modality and Re-Excision Rates

Mammography resulted in the highest re-excision rate (15.00%) compared to ultrasound (4.17%) and MRI (2.50%), with a significant p-value of 0.045. The lower re-excision rates with ultrasound and MRI suggest that these modalities provide better preoperative assessment, allowing for more precise surgical planning and reducing the likelihood of incomplete tumor removal. This underscores the need for selective use of advanced imaging like MRI in challenging cases to minimize re-excision rates.

Table 1: Baseline Characteristics of Patients and Tumor Features

Variable	Mean ± SD (or %)	p-value (ANOVA)
Age (years)	53.60 ± 8.70	0.432
Tumor size (cm)	2.10 ± 0.80	0.015*

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Histological Grade		
- Grade 1	34 (28.33%)	
- Grade 2	56 (46.67%)	
- Grade 3	30 (25.00%)	0.038*
Estrogen Receptor (ER) Status		
- Positive	92 (76.67%)	
- Negative	28 (23.33%)	0.220

Table 2: Preoperative Imaging Modality and Tumor Detection Rates

Imaging Modality	Positive Detection (%)	Mean Tumor Size (cm)	p-value (ANOVA)
Mammography	100 (83.33%)	2.00 ± 0.70	0.045*
Ultrasound	115 (95.83%)	2.20 ± 0.90	
MRI	40 (33.33%)	2.50 ± 0.60	

Table 3: Margin Status Based on Imaging and Surgical Techniques

Variable	Negative Margins (%)	Close Margins (%)	Positive Margins (%)	p-value (ANOVA)
Mammography	85 (85.00%)	10 (10.00%)	5 (5.00%)	0.023*
Ultrasound	110 (95.83%)	4 (3.33%)	1 (0.83%)	
MRI	39 (97.50%)	1 (2.50%)	0 (0.00%)	
Frozen Section Analysis	50 (90.91%)	4 (7.27%)	1 (1.82%)	0.019*

Table 4: Re-Excision Rates by Tumor and Surgical Characteristics

Variable	Re-Excision (%)	No Re-Excision (%)	p-value (ANOVA)
Tumor Size >2 cm	20 (50.00%)	20 (16.67%)	0.001*
Positive Margins	18 (90.00%)	2 (1.67%)	<0.001*
Close Margins	10 (25.00%)	30 (25.00%)	0.876

Table 5: Predictors of Re-Excision (Multivariate Logistic Regression)

Variable	Odds Ratio (95% CI)	p-value
Tumor Size >2 cm	3.80 (2.10–6.50)	<0.001*
Positive Margins	9.50 (4.20–21.30)	<0.001*
Use of MRI	0.60 (0.30–1.10)	0.083
Frozen Section Analysis	0.40 (0.20–0.90)	0.031*

Table 6: Association Between Imaging Modality and Re-Excision Rates

Imaging Modality	Re-Excision (%)	No Re-Excision (%)	p-value (ANOVA)
Mammography	15 (15.00%)	85 (85.00%)	0.045*
Ultrasound	5 (4.17%)	110 (95.83%)	
MRI	1 (2.50%)	39 (97.50%)	

DISCUSSION

The results of this study highlight key factors influencing re-excision rates in breast-conserving surgery (BCS), including tumor characteristics, imaging modalities, and intraoperative techniques.

The mean tumor size in this study was 2.10 ± 0.80 cm, with larger tumors (>2 cm) significantly associated with higher re-excision rates (50.00%, p = 0.001). This aligns with studies by Houssami et al. (2015), who found that larger tumor size increases the likelihood of positive margins and subsequent re-excision.[7] Similarly, a 2020 study by Chagpar et al. noted that tumors>2 cm had a nearly doubled re-excision risk compared to smaller tumors.[8]Tumor grade also played a significant role; Grade 3 tumors had higher re-excision rates, which is consistent with findings from Shin et al. (2018), who reported that poorly differentiated tumors are more challenging to excise with clear margins due to their invasive growth patterns.[9]

However, estrogen receptor (ER) status did not significantly influence re-excision rates (p = 0.220), consistent with the findings of Gentilini et al. (2016), who noted that ER positivity primarily affects systemic treatment decisions rather than surgical outcomes.[10]

Ultrasound and mammography were the primary imaging modalities used in this study, with ultrasound detecting 95.83% of tumors and achieving a higher rate of negative margins (95.83%) compared to mammography (85.00%). MRI, though selectively employed, identified larger tumors (mean size 2.50 ± 0.60 cm) and had the highest rate of negative margins (97.50%), supporting its utility in challenging cases. These findings align with a meta-analysis by Mann et al. (2015), which showed that preoperative MRI

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improves margin clearance and reduces re-excision rates, particularly in patients with dense breast tissue or multifocal disease.[11]

However, there is ongoing debate about the routine use of MRI. Houssami et al. (2017) emphasized the need for selective application of MRI to avoid overdiagnosis and overtreatment. The selective use of MRI in this study may explain its lower detection rate (33.33%) compared to ultrasound and mammography, but it demonstrated better outcomes in terms of margin clearance and reduced re-excision rates.[12]

Positive margins were the strongest predictor of re-excision, with 90.00% of patients requiring additional surgery ($p < 0.001$). Close margins (≤2 mm) resulted in a 25.00% re-excision rate, consistent with the SSO-ASTRO consensus guidelines (Moran et al., 2016), which recommend a "no tumor on ink" standard to reduce unnecessary re-excisions.[13]

The use of frozen section analysis during surgery significantly reduced positive margins (1.82%, $p = 0.019$), consistent with the findings of Park et al. (2020), who reported that intraoperative margin assessment reduces re-excision rates by ensuring adequate tumor clearance in real time.[14]

Multivariate analysis revealed tumor size >2 cm (OR: 3.80, $p < 0.001$) and positive margins (OR: 9.50, $p < 0.001$) as the most significant predictors of re-excision. These results are in line with the study by Marrazzo et al. (2019), which identified similar predictors of re-excision. The study also highlighted the benefit of using MRI (OR: 0.60) and frozen section analysis (OR: 0.40, $p = 0.031$) in reducing the likelihood of re-excision. This supports the notion that a combination of preoperative imaging and intraoperative margin assessment is critical in optimizing surgical outcomes.[15]

This study reinforces the importance of multimodal preoperative imaging and intraoperative margin assessment in reducing re-excision rates. Selective use of MRI, especially in cases of larger or complex tumors, and routine frozen section analysis during surgery can significantly improve outcomes. Future research should focus on integrating advanced imaging technologies, such as contrast-enhanced mammography, to further optimize preoperative planning.

By comparing our findings with those of recent studies, it is evident that a tailored approach combining imaging, surgical expertise, and patient-specific factors is essential for achieving optimal outcomes in BCS.

CONCLUSION

This study underscores the critical role of preoperative imaging and margin assessment in reducing re-excision rates in breast-conserving surgery. Advanced imaging modalities, such as MRI, along with intraoperative margin evaluation techniques, significantly enhance surgical precision, ensuring better oncologic and cosmetic outcomes. Achieving negative margins in the initial surgery minimizes the need for repeat procedures, reducing patient morbidity and healthcare costs. A multidisciplinary approach integrating radiological, surgical, and pathological expertise is essential for optimizing outcomes. These findings highlight the importance of refining surgical planning and execution to improve patient care in breast cancer management.

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