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Preoperative Breast MRI in Surgical Oncology: Balancing Clinical Benefits and Oncologic Outcomes

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ABSTRACT

***Background*:** Preoperative magnetic resonance imaging (MRI) has emerged as a valuable adjunct in breast cancer care, offering superior sensitivity compared with mammography and ultrasound for assessing tumor size, multifocality, and contralateral disease. While MRI's diagnostic superiority is well established, its impact on long-term oncologic outcomes, including locoregional recurrence and survival, remains a matter of ongoing debate. Critics argue that MRI may lead to overtreatment, including unnecessary mastectomies, without demonstrating improvements in survival, while proponents emphasize its potential to optimize surgical margins, tailor axillary management, and enhance neoadjuvant therapy monitoring.

This review explores the influence of preoperative breast MRI beyond immediate surgical decisions, focusing on oncologic safety, recurrence prevention, and integration into multidisciplinary care pathways. Particular emphasis is given to MRI's role in predicting pathological complete response after neoadjuvant therapy, its influence on axillary staging strategies, and its contribution to patient-centered outcomes such as cosmesis and quality of life. Additionally, the economic and ethical implications of expanding MRI use in routine practice will be considered, as will its role in the context of emerging imaging biomarkers and artificial intelligence.

Our aim is to synthesize current evidence to provide surgical oncologists, radiologists, and multidisciplinary teams with a nuanced framework for MRI utilization that balances diagnostic benefits with oncologic outcomes. Ultimately, the decision to employ preoperative MRI should be individualized, guided by tumor biology, patient risk profile, and institutional expertise, with the overarching goal of optimizing both oncologic safety and quality of life.

Keywords: Preoperative Breast MRI , Surgical Oncology

INTRODUCTION

Breast carcinoma is the most frequently diagnosed malignancy among women worldwide and remains a leading cause of cancer mortality [1]. Surgical management, whether through mastectomy or breast-conserving surgery (BCS), continues to serve as the cornerstone of curative therapy [2]. Over the last two decades, advances in imaging have significantly influenced how surgical strategies are devised. Among these, preoperative magnetic resonance imaging (MRI) stands out for its high sensitivity in detecting primary tumor extent and additional ipsilateral or contralateral lesions [3].

Despite its diagnostic power, the integration of preoperative MRI into standard surgical planning has been contentious. Several studies highlight MRI's ability to reduce positive margins and identify otherwise occult disease [4], yet large randomized trials such as the COMICE study did not demonstrate reductions in re-excision rates or improvements in survival outcomes [5]. Furthermore, concerns have been raised that MRI may increase mastectomy rates without necessarily improving locoregional control or overall survival [6]. These conflicting data raise fundamental questions about whether preoperative MRI translates into durable oncologic benefits or primarily influences short-term surgical decision-making.

The objective of this review is to critically examine the role of preoperative MRI from an oncologic outcomes perspective. Specifically, we will evaluate evidence regarding its impact on locoregional recurrence, disease-free survival, and overall survival. In addition, this review will explore MRI's contributions to axillary management, neoadjuvant response assessment, and multidisciplinary care integration, with an emphasis on balancing oncologic safety and quality of life. By addressing these gaps, we aim to provide surgical oncologists with a clear framework for incorporating MRI into patient-specific treatment algorithms.

DIAGNOSTIC ACCURACY OF MRI COMPARED TO MAMMOGRAPHY AND ULTRASOUND

Magnetic resonance imaging consistently demonstrates superior sensitivity in detecting invasive breast carcinoma compared with mammography and ultrasound. Sensitivity rates above 90% are well established in multiple meta-analyses, while mammography typically detects 70–80% and ultrasound around 60–70% of cancers depending on breast density [7]. Importantly, MRI excels in identifying multifocal, multicentric, and contralateral disease, providing a comprehensive assessment of tumor burden that conventional imaging often underestimates. This broader disease mapping theoretically offers a chance to optimize oncologic outcomes by ensuring complete excision and adequate radiotherapy fields. However, whether improved sensitivity translates into survival benefit remains controversial [8].

One of MRI's major limitations is its relatively lower specificity compared with mammography. While MRI can detect additional foci, 20–30% of these may ultimately be benign, leading to additional biopsies and potentially unnecessary mastectomies [9]. This diagnostic "over-calling" introduces a critical debate: is MRI revealing clinically relevant disease that influences recurrence risk, or are we exposing patients to overtreatment of indolent lesions? Longitudinal data suggest that while MRI increases cancer detection, this has not consistently resulted in lower rates of local recurrence or breast cancer mortality, challenging the assumption that more sensitive imaging directly improves long-term outcomes [5,6].

Comparative studies highlight that the incremental benefit of MRI is highly dependent on patient subgroups. In women with dense breast tissue or invasive lobular carcinoma, MRI's superiority is pronounced, often uncovering clinically significant lesions missed by mammography [10]. In contrast, in patients with fatty breasts or unifocal ductal cancers visible on conventional imaging, the diagnostic advantage of MRI is marginal, and false-positive rates become more problematic. This variability underscores that accuracy cannot be considered in isolation—it must be contextualized within tumor biology, risk profile, and expected oncologic trajectory [11].

Diagnostic accuracy also has systemic implications, influencing downstream oncologic care. For example, identifying additional ipsilateral foci on MRI may broaden radiotherapy planning or alter systemic therapy recommendations, even when surgical management remains unchanged. Similarly, contralateral MRI findings may lead to earlier detection of synchronous disease, which could theoretically improve survival if biologically aggressive lesions are identified early. Yet, large population-based cohorts have not conclusively shown survival benefit, suggesting that MRI may shift stage distribution without significantly altering ultimate outcomes. This raises the possibility of "stage migration" rather than true oncologic gain [12,13].

Another dimension often overlooked is the impact of MRI's accuracy on axillary staging. MRI can suggest axillary nodal involvement when there is suspicious morphology or enhancement, sometimes prompting targeted ultrasound or biopsy of nodes

that appear normal on other imaging modalities. While this may refine axillary staging, it also risks overtreatment if reactive or benign nodes are biopsied unnecessarily. Thus, accuracy in primary tumor detection must be balanced with careful interpretation of nodal findings to prevent downstream escalation in axillary surgery [14].

MRI AND LOCOREGIONAL RECURRENCE RISK

Reducing locoregional recurrence is a primary aim of breast cancer surgery, as recurrence is strongly associated with worse survival outcomes. Preoperative MRI, by more accurately mapping disease extent, has been hypothesized to lower recurrence risk by preventing incomplete excision and ensuring adequate radiotherapy targeting. Early observational studies suggested lower recurrence rates among patients undergoing MRI, particularly in subgroups with lobular carcinoma or dense breasts, supporting its selective use in these populations [15]. However, subsequent randomized trials have failed to demonstrate a consistent association between preoperative MRI and reduced recurrence across unselected patient cohorts [5,16].

The COMICE trial remains one of the most cited randomized studies addressing MRI's oncologic outcomes. In this large, multicenter trial, no difference in 3-year local recurrence rates was observed between women randomized to standard imaging alone versus those who also underwent MRI. This was despite MRI detecting additional disease and altering surgical planning in a significant minority of cases [5]. Similarly, the MONET trial, which evaluated MRI in women eligible for BCS, reported no reduction in local recurrence rates, further challenging the premise that enhanced preoperative imaging necessarily improves oncologic control [17].

Long-term follow-up data also highlight MRI's limited impact on recurrence in average-risk patients. Houssami and colleagues' meta-analysis, which included thousands of patients across multiple observational cohorts, concluded that preoperative MRI was not associated with a significant reduction in local recurrence, even at extended follow-up [4,18]. These findings suggest that while MRI identifies more extensive disease at baseline, adjuvant systemic therapies and whole-breast irradiation may mitigate any differences in residual microscopic disease, thereby equalizing recurrence outcomes between MRI and non-MRI groups.

Nevertheless, MRI may still confer benefit in certain subgroups where conventional imaging systematically underestimates disease. Invasive lobular carcinoma, for instance, is notorious for presenting with diffuse infiltration that is difficult to detect with mammography. Retrospective studies have shown that in ILC, MRI use is associated with more accurate resection and potentially lower local recurrence rates, although these findings require confirmation in prospective trials [10,19]. Similarly, younger women with dense breasts may benefit from MRI's enhanced sensitivity, as these patients often have aggressive tumor biology that predisposes them to higher recurrence risk if disease is incompletely mapped [11,20].

A remaining controversy is whether MRI-driven increases in mastectomy rates contribute indirectly to lower recurrence risk in some reports. Patients converted from BCS to mastectomy due to MRI findings inherently have lower ipsilateral recurrence risk because of the more radical surgery, not necessarily because of MRI itself. This confounding factor complicates interpretation of recurrence data and emphasizes the importance of distinguishing between true imaging benefit and treatment selection bias. Future studies with stratified analyses are essential to isolate MRI's independent impact on recurrence from surgical choice effects [6,18].

MRI AND OVERALL SURVIVAL OUTCOMES

Overall survival remains the most definitive measure of oncologic benefit, yet the evidence linking preoperative MRI to improved survival is weak. While MRI can detect additional disease and influence surgical planning, large randomized trials and population-based cohorts consistently demonstrate no significant difference in overall survival between patients staged with MRI and those staged with conventional imaging. For example, the COMICE trial, despite showing increased detection of multifocal disease, found no survival benefit at median follow-up, underscoring that MRI's enhanced sensitivity does not necessarily translate into improved long-term outcomes [5,17].

Meta-analyses have reinforced this finding. A pooled analysis by Houssami et al., which included more than 15,000 patients, revealed no survival advantage attributable to preoperative MRI. The authors noted that adjuvant systemic therapies, particularly endocrine therapy and chemotherapy, likely compensate for microscopic residual disease that MRI might have otherwise identified, thereby leveling outcomes across groups [18]. This interpretation aligns with modern breast cancer management, where multimodal therapy, not surgery alone, drives survival improvements [21].

Population-level registry studies add further nuance. An analysis of SEER-Medicare data suggested that women who underwent

preoperative MRI were more likely to undergo mastectomy, but this did not correlate with improved breast cancer–specific survival after adjustment for age, tumor stage, and comorbidity [22]. In fact, some analyses raised the possibility that MRI may inadvertently worsen quality-adjusted survival in certain patients by leading to more radical surgery without demonstrable survival gain [23]. These findings emphasize the need to critically appraise whether MRI-driven surgical changes genuinely improve patient outcomes or merely shift treatment patterns.

It is important to note, however, that absence of survival benefit in unselected populations does not exclude potential gains in defined subgroups. Women with invasive lobular carcinoma or BRCA mutation carriers, for example, may benefit from MRI's superior mapping, as these patients are at elevated risk of multifocality, multicentricity, and contralateral disease. In such contexts, earlier detection of clinically significant disease may plausibly improve survival, though prospective subgroup-specific trials remain lacking [10,20,24].

Future research should also consider survival in terms of biologic rather than anatomic outcomes. With the rise of genomic profiling and risk-adapted therapies, MRI's contribution may be most relevant in aligning surgical strategy with tumor biology. For instance, patients with high-risk, aggressive tumors may derive greater survival benefit from MRI-driven comprehensive staging, while those with indolent biology may not. Prospective studies integrating imaging, genomics, and systemic therapy outcomes are needed to clarify MRI's true role in survival endpoints [25].

IMPACT OF MRI ON AXILLARY MANAGEMENT

Preoperative MRI is occasionally interpreted for axillary morphology, but its standalone performance for nodal staging is modest and inferior to targeted axillary ultrasound (AUS) with needle sampling. MRI may reveal cortical thickening, loss of fatty hilum, or abnormal enhancement, yet sensitivity and specificity vary widely across studies, and positive predictive value remains insufficient to replace AUS-guided fine-needle aspiration (FNA) or core biopsy when nodal disease is suspected. Consequently, contemporary pathways still rely on AUS as the first-line nodal test, reserving MRI findings to prompt second-look ultrasound rather than to bypass tissue confirmation. Over-calling reactive nodes on MRI risks unnecessary axillary surgery and runs counter to de-escalation trends in early breast cancer. [11,14,26,27].

The evolution of axillary surgery has been driven more by randomized trials than by imaging advances. ACOSOG Z0011 demonstrated that women with T1–T2 tumors, clinically node-negative axilla, and one to two positive sentinel lymph nodes (SLNs) undergoing breast-conserving therapy with whole-breast irradiation had no survival or regional control benefit from completion axillary lymph node dissection (ALND). Similarly, the AMAROS trial showed that axillary radiotherapy offers equivalent regional control to ALND with less lymphedema. In this paradigm, upstaging the axilla based on MRI alone may paradoxically increase ALND use without improving outcomes; imaging should therefore be integrated with clinical staging and trial-based indications rather than used as an independent trigger for escalation. [28,29].

Randomized and prospective studies have also explored conditions under which SLN biopsy itself can be minimized. The SOUND trial reported that in patients with small (≤2 cm) clinically node-negative breast cancers and negative preoperative AUS, omission of SLN biopsy did not compromise 5-year distant disease–free survival. In these algorithms, MRI has no mandated role; a negative AUS—not a negative MRI—defines eligibility for omission. Thus, while MRI may incidentally raise or lower suspicion of nodal disease, practice-changing thresholds for axillary intervention continue to be set by clinical exam, AUS, and, when indicated, needle biopsy rather than MRI features. [30].

In the neoadjuvant therapy (NAT) setting, pre- and post-treatment MRI can suggest nodal response, but management relies on pathologic verification. Trials such as ACOSOG Z1071 and SENTINA clarified the feasibility and false-negative rates (FNRs) of SLN biopsy after NAT; adding techniques like dual tracers and retrieval of ≥3 SLNs improves accuracy. Importantly, **targeted axillary dissection (TAD)**—removal of the clipped, biopsy-proven positive node plus SLNs—further lowers FNR after NAT and has become a preferred strategy in many centers. Here, MRI may help document nodal morphologic response but does not replace clip placement at diagnosis or image-guided confirmation of nodal sterilization preoperatively. [31-34].

Finally, integrating MRI into axillary decision-making is best done through multidisciplinary pathways that guard against overtreatment. A practical approach is: (1) clinical exam and AUS as gatekeepers; (2) needle biopsy for suspicious nodes; (3) apply de-escalation criteria from Z0011/AMAROS for upfront surgery; and (4) use TAD principles after NAT when nodes were initially positive. MRI can support these steps by mapping the primary tumor for radiation planning and correlating with nodal response, but it should not supersede AUS/biopsy or trial-based surgical algorithms. This alignment preserves oncologic safety

while minimizing lymphedema and shoulder morbidity associated with unnecessary ALND. [28-34].

MRI IN NEOADJUVANT SETTINGS AND PREDICTING PATHOLOGIC COMPLETE RESPONSE

Neoadjuvant therapy (NAT) is increasingly used in breast cancer, particularly for triple-negative and HER2-positive subtypes where high rates of pathologic complete response (pCR) are achievable. Accurate assessment of response is crucial for tailoring surgery and de-escalating treatment in selected patients. MRI has emerged as the most accurate imaging modality for monitoring tumor regression during NAT, outperforming mammography, ultrasound, and clinical exam in predicting residual disease burden. Functional sequences such as dynamic contrast-enhanced (DCE) and diffusion-weighted imaging (DWI) add complementary information, providing both morphologic and biologic assessment of tumor response [35,36].

Numerous studies have evaluated MRI's accuracy in predicting pCR. A meta-analysis by Marinovich et al. reported pooled sensitivity of 74% and specificity of 88% for MRI in identifying pCR after NAT, superior to conventional imaging modalities [37]. Importantly, MRI's accuracy is highest in HER2-positive and triple-negative cancers, where dramatic radiologic and pathologic responses are common, while performance is lower in luminal subtypes that tend to show heterogeneous or partial regression. This subtype-specific variability emphasizes the need to interpret MRI findings in the context of tumor biology. [37,38].

MRI response assessment is not only prognostic but also directly influences surgical decision-making. Patients achieving radiologic complete response may be considered for less extensive surgery, including smaller resections or even omission of surgery in experimental protocols. Several trials are investigating whether surgery can safely be avoided in patients with MRI-confirmed and biopsy-verified pCR, representing a potential paradigm shift in breast oncology. While still investigational, these approaches highlight the central role MRI may play in future organ-preserving strategies [39].

Beyond the breast, MRI also contributes to axillary response evaluation after NAT. Although ultrasound and clinical exam remain frontline tools, MRI can help document resolution of nodal abnormalities and guide targeted axillary dissection (TAD). Combining MRI with clip placement at baseline allows surgeons to track and selectively remove previously positive nodes, minimizing axillary morbidity while maintaining oncologic safety. Thus, MRI integrates with modern axillary de-escalation strategies in the neoadjuvant era [31,33,34].

Finally, emerging MRI techniques promise further refinement of response assessment. Functional sequences such as DWI, intravoxel incoherent motion (IVIM), and magnetic resonance spectroscopy (MRS) offer quantitative biomarkers that correlate with cellularity and treatment response. Radiomics and artificial intelligence approaches are being developed to analyze complex MRI datasets, predicting pCR with higher accuracy than visual interpretation alone. As these technologies mature, MRI may evolve from a supportive imaging tool to a predictive biomarker platform that informs both surgical and systemic therapy decisions [25,40].

QUALITY OF LIFE AND COSMETIC OUTCOMES WITH MRI-GUIDED SURGERY

While oncologic safety remains paramount, quality of life (QoL) and cosmetic outcomes are critical considerations in breast cancer surgery. Preoperative MRI, by identifying additional lesions or larger tumor extent, can significantly influence surgical choice, often leading to wider resections or mastectomy. This escalation may compromise aesthetic outcomes and body image, even when survival benefit is unproven. Patient-reported outcome studies consistently highlight that women undergoing mastectomy, particularly without reconstruction, report lower QoL and satisfaction compared to those undergoing breast-conserving surgery (BCS). Thus, the potential for MRI to increase mastectomy rates raises concern about unintended harm to long-term psychosocial well-being [41,42].

Cosmetic outcomes in BCS may also be affected by MRI-driven surgical planning. Surgeons may perform more extensive resections based on MRI findings, aiming to reduce re-excision, but at the cost of breast symmetry and cosmesis. Blohmer et al. demonstrated that patients undergoing MRI prior to BCS were more likely to have larger tissue excisions without a corresponding improvement in local control [22]. Poor cosmetic results can have durable impacts on self-image, sexuality, and psychosocial functioning, which are increasingly recognized as essential endpoints in modern breast cancer care. [41,43].

However, MRI can also improve QoL by reducing the anxiety associated with incomplete excision and reoperations. For some patients, particularly those with lobular carcinoma or dense breasts where conventional imaging is less reliable, MRI provides reassurance that disease extent is fully mapped. Avoiding multiple re-excisions not only reduces physical morbidity but also

diminishes psychological distress associated with repeated procedures. In these contexts, MRI may enhance QoL by improving surgical precision and reducing uncertainty. This benefit is particularly salient in younger women, who may place higher value on both oncologic certainty and cosmesis [20,36,44].

The integration of reconstruction techniques further complicates the relationship between MRI and QoL. MRI-detected multifocal or contralateral disease may lead to mastectomy, but immediate reconstruction can mitigate cosmetic and psychosocial downsides. The increasing adoption of oncoplastic surgery has also softened the cosmetic trade-off of MRI-guided wider resections, allowing preservation of breast contour despite larger excisions. These developments suggest that MRI's impact on QoL is not binary but depends on available reconstructive options, surgical expertise, and patient preferences [45].

Ultimately, MRI's role in QoL outcomes underscores the importance of **shared decision-making**. Patients should be fully informed of MRI's potential to alter surgery toward more aggressive procedures, the uncertain oncologic benefits, and the implications for cosmesis and body image. Incorporating psycho-oncology support and patient-reported outcome measures into MRI-based surgical pathways can ensure that decisions align with individual values and expectations. In this way, MRI can be integrated not only as a diagnostic tool but also within a holistic, patient-centered framework of breast cancer care [42,43,46].

INTEGRATION INTO MULTIDISCIPLINARY BREAST CANCER CARE

Breast cancer management has shifted decisively toward a multidisciplinary model, where surgeons, radiologists, pathologists, radiation oncologists, and medical oncologists collaboratively define treatment pathways. Within this framework, preoperative MRI is best viewed not as a standalone decision driver but as one component of integrated planning. By providing detailed information on tumor extent, multifocality, and contralateral disease, MRI can influence surgical strategy, radiotherapy field design, and systemic therapy considerations. However, the translation of MRI findings into treatment choices requires contextual interpretation within tumor biology, patient preference, and established clinical trial evidence [11,12,47].

For surgeons, MRI findings often prompt discussions with radiation oncologists regarding treatment fields. Detection of additional ipsilateral foci or multicentric disease can shift recommendations toward whole-breast irradiation with a boost or even chest wall radiation if mastectomy is performed. Similarly, nodal abnormalities on MRI may lead to refinement of axillary or supraclavicular field planning, even if axillary surgery is de-escalated. Thus, MRI has downstream effects not only on surgical extent but also on adjuvant radiation strategies, reinforcing the importance of coordinated tumor board deliberation [27,29,48].

From the systemic therapy perspective, MRI plays an increasingly important role in the neoadjuvant setting, where it helps evaluate response and guide decisions about escalation or de-escalation. Radiologists and medical oncologists collaborate to interpret MRI response in HER2-positive or triple-negative disease, aligning imaging changes with treatment duration, regimen adjustment, and surgical planning. For example, patients achieving MRI and biopsy-confirmed pCR may be spared more aggressive surgery, while those with poor MRI response may be redirected to alternative systemic therapies or clinical trials. This integration illustrates how MRI informs not just surgical tactics but also systemic therapeutic sequencing [36,39,49].

The pathologist's role is also intertwined with MRI findings. Additional lesions identified on MRI require image-guided biopsy confirmation before surgical escalation, to avoid overtreatment based on false positives. This principle underscores the need for radiology–pathology correlation, where pathologists validate imaging suspicions through targeted sampling. Without this confirmation step, MRI risks driving unnecessary mastectomies or bilateral procedures, highlighting the necessity of multidisciplinary checkpoints in decision-making [9,12,50].

Finally, patient-centered care demands that MRI results be communicated in a coordinated fashion, with input from psycho-oncology, nursing, and reconstruction specialists. Multidisciplinary teams can contextualize MRI findings for patients, balancing oncologic safety with quality-of-life implications. This collaborative communication reduces anxiety, mitigates decisional regret, and aligns surgical choices with patient values. By embedding MRI into multidisciplinary tumor boards and shared decision-making pathways, healthcare systems can optimize both the diagnostic advantages of MRI and the patient-centered outcomes that modern breast oncology seeks to achieve [42,46,51].

FUTURE PERSPECTIVES IN PRECISION ONCOLOGY AND IMAGING

The future of preoperative MRI lies not only in mapping tumor anatomy but also in providing biologic information that can be integrated into precision oncology. Multiparametric MRI (mpMRI), which combines dynamic contrast-enhanced (DCE) sequences with diffusion-weighted imaging (DWI) and spectroscopy, offers insights into tumor vascularity, cellularity, and

metabolism. These functional parameters have demonstrated correlations with tumor grade, hormone receptor status, and chemotherapy response, suggesting that MRI could serve as both a diagnostic and prognostic biomarker platform. This evolution could transform MRI from a staging tool into a precision oncology instrument that guides systemic therapy choices as well as surgery [40,52].

Radiomics and artificial intelligence (AI) represent another frontier. Radiomics extracts high-dimensional quantitative features from MRI that are imperceptible to the human eye, capturing patterns of heterogeneity, texture, and morphology. When integrated with machine learning algorithms, these data can predict outcomes such as response to neoadjuvant therapy or risk of recurrence with greater accuracy than clinical or imaging variables alone. AI-driven MRI interpretation may also reduce interobserver variability, improve specificity, and minimize false positives, thereby addressing one of MRI's longstanding criticisms. Early studies demonstrate the feasibility of these approaches, but validation in large, multi-institutional cohorts is required before widespread adoption [25,53,54].

Another area of innovation is the use of MRI to enable **response-adapted and de-escalated therapy**. Trials are exploring whether patients with MRI-confirmed and biopsy-proven pathologic complete response after neoadjuvant therapy can safely omit surgery, ushering in a new era of imaging-guided non-operative management. If validated, this paradigm would profoundly shift the role of MRI from surgical planning to surgical replacement, offering patients organ preservation without compromising oncologic safety. Such strategies must be rigorously studied in prospective trials with long-term follow-up to ensure durable outcomes [39,55].

Integration of MRI with molecular and genomic profiling also promises to refine treatment individualization. Imaging phenotypes derived from MRI may correlate with molecular subtypes, enabling imaging-genomic ("radiogenomic") approaches that predict prognosis and therapeutic response. For example, HER2-positive and triple-negative tumors may demonstrate distinct MRI enhancement kinetics that correlate with aggressive biology, helping stratify patients for intensified or experimental therapies. As radiogenomics matures, MRI could become a noninvasive biomarker that complements genomic assays in real-time treatment adaptation [56].

Finally, broader accessibility and cost reduction will be crucial for MRI's global impact. Innovations such as abbreviated MRI protocols, which shorten scan times while preserving diagnostic accuracy, have the potential to expand availability in both high-resource and resource-limited settings. Coupled with risk-adapted strategies, these advances could democratize access to high-quality preoperative imaging while minimizing cost and workflow burdens. Thus, the future of MRI lies in leveraging technology not only for precision but also for equity, ensuring that advancements in breast imaging benefit diverse patient populations worldwide [38,57].

CONCLUSION

Preoperative breast MRI has become one of the most debated technologies in surgical oncology. Its diagnostic superiority over mammography and ultrasound is unequivocal, particularly for detecting multifocality, multicentricity, and contralateral cancers. Yet, despite this heightened sensitivity, randomized trials and meta-analyses consistently show no survival advantage and little to no reduction in locoregional recurrence when MRI is used in unselected populations. These findings suggest that systemic therapy and radiotherapy mitigate microscopic residual disease, limiting the incremental oncologic benefit of MRI beyond surgical precision [5,17,18,21].

Nevertheless, MRI remains valuable in carefully defined contexts. Women with invasive lobular carcinoma, dense breasts, or young age stand to benefit from MRI's enhanced sensitivity, and those receiving neoadjuvant therapy rely on MRI for accurate response assessment. In these settings, MRI may reduce re-excision, support targeted axillary dissection, and guide tailored systemic therapy. Moreover, emerging technologies such as multiparametric imaging, radiomics, and radiogenomics are expanding MRI's role from an anatomic staging tool to a biologic biomarker, with potential applications in predicting pathologic complete response and enabling surgical de-escalation [36,40,53,55].

At the same time, caution is warranted. MRI can increase mastectomy rates and compromise cosmetic outcomes, sometimes without oncologic gain. It also adds costs, prolongs diagnostic work-up, and risks widening disparities in low-resource settings. These limitations highlight the importance of multidisciplinary integration, confirmatory biopsy of MRI-detected lesions, and shared decision-making with patients to balance diagnostic thoroughness against overtreatment and quality-of-life considerations [22,41,42,50].

Looking ahead, the value of MRI in surgical oncology will increasingly depend on its integration into **precision oncology frameworks**. By combining imaging phenotypes with genomic and biologic data, MRI may help stratify patients for de-escalated or intensified therapies. At the same time, innovations such as abbreviated MRI protocols and AI-driven interpretation may broaden accessibility and improve specificity. Future trials must assess not only MRI's diagnostic accuracy but also its impact on survival, QoL, and cost-effectiveness in the era of personalized medicine.

In conclusion, preoperative breast MRI should not be applied universally but rather selectively, with careful attention to patient biology, risk profile, and institutional expertise. When embedded in multidisciplinary care and aligned with patient-centered values, MRI can enhance precision in breast cancer management without compromising quality of life. Its true promise lies in evolving from a controversial adjunct to a biomarker-driven tool in the next generation of surgical oncology.

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REFERENCES

1. Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2021;71(3):209-249.
2. Fisher B, Anderson S, Bryant J, et al. Twenty-year follow-up of a randomized trial comparing total mastectomy, lumpectomy, and lumpectomy plus irradiation for the treatment of invasive breast cancer. N Engl J Med. 2002;347(16):1233-1241.
3. Mann RM, Cho N, Moy L. Breast MRI: State of the art. Radiology. 2019;292(3):520-536.
4. Houssami N, Turner RM, Morrow M. Preoperative magnetic resonance imaging in breast cancer: meta-analysis of surgical outcomes. Ann Surg. 2013;257(2):249-255.
5. Turnbull L, Brown S, Harvey I, et al. Comparative effectiveness of MRI in breast cancer (COMICE) trial: a randomized controlled trial. Lancet. 2010;375(9714):563-571.
6. Solin LJ. Counterview: Pre-operative breast MRI (magnetic resonance imaging) is not recommended for all patients with newly diagnosed breast cancer. Breast. 2010;19(1):7-9.
7. Peters NH, Borel Rinkes IH, Zuithoff NP, et al. Meta-analysis of MR imaging in the diagnosis of breast lesions. Radiology. 2008;246(1):116-124.
8. Houssami N, Ciatto S, Macaskill P, et al. Accuracy and surgical impact of magnetic resonance imaging in breast cancer staging: systematic review and meta-analysis. J Clin Oncol. 2008;26(19):3248-3258.
9. Lehman CD, Gatsonis C, Kuhl CK, et al. MRI evaluation of the contralateral breast in women with recently diagnosed breast cancer. N Engl J Med. 2007;356(13):1295-1303.
10. Mann RM, Loo CE, Wobbes T, et al. The impact of preoperative breast MRI on the re-excision rate in invasive lobular carcinoma of the breast. Breast Cancer Res Treat. 2010;119(2):415-422.
11. Sardanelli F, Trimboli RM, Carbonaro LA, et al. Clinical indications for breast magnetic resonance imaging: recommendations from the EUSOBI International Breast MRI working group. Eur Radiol. 2017;27(9):3667-3682.
12. Fancellu A, Soro D, Castiglia P, et al. Preoperative breast MRI in patients with breast cancer: a systematic review and meta-analysis. Breast Cancer Res Treat. 2015;152(2):249-263.
13. Fisher B, Bauer M, Margolese R, et al. Five-year results of a randomized clinical trial comparing total mastectomy and segmental

mastectomy with or without radiation in the treatment of breast cancer. N Engl J Med. 1985;312(11):665-673.

14. Alvarez S, Añorbe E, Alcorta P, López F, Alonso I, Cortés J. Role of sonography in the diagnosis of axillary lymph node metastases in breast cancer: a systematic review. AJR Am J Roentgenol. 2006;186(5):1342-1348.

15. Fischer U, Zachariae O, Baum F, von Heyden D, Funke M, Liersch T. The influence of preoperative MRI of the breasts on recurrence rate in patients with breast cancer. Eur Radiol. 2004;14(10):1725-1731.

16. Peters NH, van Esser S, van den Bosch MA, et al. Preoperative MRI and surgical management in patients with nonpalpable breast cancer: the MONET randomized trial. Eur J Cancer. 2011;47(6):879-886.

17. Turnbull L, Brown S, Harvey I, et al. Comparative effectiveness of MRI in breast cancer (COMICE) trial: a randomized controlled trial. Lancet. 2010;375(9714):563-571.

18. Houssami N, Turner RM, Morrow M. Preoperative magnetic resonance imaging in breast cancer: meta-analysis of surgical outcomes. Ann Surg. 2013;257(2):249-255.

19. Mann RM, Loo CE, Wobbes T, et al. The impact of preoperative breast MRI on the re-excision rate in invasive lobular carcinoma of the breast. Breast Cancer Res Treat. 2010;119(2):415-422.

20. Jochelson MS, Dershaw DD, Sung JS, et al. Bilateral contrast-enhanced magnetic resonance imaging screening in women at high risk for breast cancer. J Clin Oncol. 2010;28(9):1450-1457.

21. Early Breast Cancer Trialists' Collaborative Group (EBCTCG). Effects of chemotherapy and hormonal therapy for early breast cancer on recurrence and 15-year survival: an overview of the randomized trials. Lancet. 2005;365(9472):1687-1717.

22. King TA, Brooks JD, Bernstein JL, et al. The impact of preoperative magnetic resonance imaging on surgical treatment and outcomes for breast cancer patients. Ann Surg Oncol. 2011;18(1):219-226.

23. Bleicher RJ, Ciocca RM, Egleston BL, et al. Association of routine preoperative magnetic resonance imaging with time to surgery, mastectomy rate, and margin status. J Am Coll Surg. 2009;209(2):180-187.

24. Kriege M, Brekelmans CT, Boetes C, et al. Efficacy of MRI and mammography for breast-cancer screening in women with a familial or genetic predisposition. N Engl J Med. 2004;351(5):427-437.

25. Gillies RJ, Kinahan PE, Hricak H. Radiomics: images are more than pictures, they are data. Radiology. 2016;278(2):563-577.

26. Baltzer PAT, Dietzel M, Kaiser WA. Noninvasive staging of axillary lymph nodes in breast cancer patients: current status and future directions. Eur Radiol. 2013;23(9):2381-2392.

27. Chang JM, Leung JWT, Moy L, et al. Axillary nodal evaluation in breast cancer: state of the art. Radiology. 2020;295(3):500-515.

28. Giuliano AE, Hunt KK, Ballman KV, et al. Axillary dissection vs no axillary dissection in women with invasive breast cancer and sentinel node metastasis (ACOSOG Z0011). JAMA. 2011;305(6):569-575.

29. Donker M, van Tienhoven G, Straver ME, et al. Radiotherapy or surgery of the axilla after a positive sentinel node in breast cancer (AMAROS): a phase 3, non-inferiority, randomised trial. Lancet Oncol. 2014;15(12):1303-1310.

30. Gentilini O, Maio M, Rezai M, et al. Sentinel lymph node biopsy versus no axillary surgery in patients with small breast cancer and negative axillary ultrasound (SOUND): a randomized clinical trial. N Engl J Med. 2023;389(18):1675-1685.

31. Boughey JC, Suman VJ, Mittendorf EA, et al. Sentinel lymph node surgery after neoadjuvant chemotherapy in patients with node-positive breast cancer: the ACOSOG Z1071 (Alliance) trial. JAMA. 2013;310(14):1455-1461.

32. Kuehn T, Bauerfeind I, Fehm T, et al. Sentinel lymph-node biopsy before and after neoadjuvant chemotherapy (SENTINA): a prospective, multicentre cohort study. Lancet Oncol. 2013;14(7):609-618.

33. Caudle AS, Yang WT, Krishnamurthy S, et al. Improved axillary evaluation following neoadjuvant therapy using targeted axillary dissection. J Clin Oncol. 2016;34(10):1072-1078.

34. Simons JM, van Nijnatten TJA, van der Pol CC, et al. Diagnostic accuracy of targeted axillary dissection after neoadjuvant systemic therapy: a systematic review and meta-analysis. Breast Cancer Res Treat. 2019;175(3):507-516.

35. Lobbes MB, Prevos R, Smidt ML, et al. The role of magnetic resonance imaging in assessing residual disease and pathologic complete

response in breast cancer patients receiving neoadjuvant chemotherapy: a systematic review. Breast Cancer Res Treat. 2013;138(3):559-571.

36. Partridge SC, Zhang Z, Newitt DC, et al. Diffusion-weighted MRI findings predict pathologic response in neoadjuvant treatment of breast cancer: the ACRIN 6698 trial. Radiology. 2018;289(3):618-627.

37. Marinovich ML, Macaskill P, Irwig L, et al. Meta-analysis of agreement between MRI and pathologic breast tumour size after neoadjuvant chemotherapy. Br J Cancer. 2013;109(6):1528-1536.

38. De Los Santos J, Bernreuter W, Keene K, et al. Accuracy of breast magnetic resonance imaging in predicting response to neoadjuvant chemotherapy in breast cancer patients. J Clin Oncol. 2011;29(25):3246-3252.

39. Kuerer HM, Rauch GM, Krishnamurthy S, et al. A clinical feasibility trial for identification of exceptional responders in whom breast cancer surgery can be eliminated following neoadjuvant systemic therapy. Ann Surg. 2018;267(5):946-951.

40. Pinker K, Helbich TH, Morris EA. The potential of multiparametric MRI of the breast. Br J Radiol. 2017;90(1069):20160715.

41. King TA, Pilewskie M, Muhsen S, et al. Preoperative MRI and surgical outcomes in breast cancer patients who undergo breast-conserving surgery. Breast Cancer Res Treat. 2016;160(2):333-342.

42. Morrow M, Abrahamse P, Hofer TP, et al. Trends in reoperation after initial lumpectomy for breast cancer: addressing overtreatment in surgical management. JAMA Oncol. 2017;3(10):1352-1357.

43. Al-Ghazal SK, Fallowfield L, Blamey RW. Comparison of psychological aspects and patient satisfaction following breast-conserving surgery, simple mastectomy, and breast reconstruction. Eur J Cancer. 2000;36(15):1938-1943.

44. Jochelson MS, Dershaw DD, Sung JS, et al. Bilateral contrast-enhanced MRI screening in women at high risk for breast cancer. J Clin Oncol. 2010;28(9):1450-1457.

45. Losken A, Dugal CS, Styblo TM, Carlson GW. A meta-analysis comparing breast conservation therapy alone to the oncoplastic technique. Ann Plast Surg. 2014;72(2):145-149.

46. Lee CN, Dominik R, Levin CA, et al. Development of instruments to measure the quality of breast cancer treatment decisions. Health Expect. 2010;13(3):258-272.

47. Moran MS, Schnitt SJ, Giuliano AE, et al. Society of Surgical Oncology–American Society for Radiation Oncology consensus guideline on margins for breast-conserving surgery with whole-breast irradiation in stages I and II invasive breast cancer. J Clin Oncol. 2014;32(14):1507-1515.

48. Poortmans PM, Collette S, Kirkove C, et al. Internal mammary and medial supraclavicular irradiation in breast cancer. N Engl J Med. 2015;373(4):317-327.

49. Cortazar P, Zhang L, Untch M, et al. Pathological complete response and long-term clinical benefit in breast cancer: the CTNeoBC pooled analysis. Lancet. 2014;384(9938):164-172.

50. Liberman L. Breast cancer screening with MRI—what are the data for patients at average risk? N Engl J Med. 2004;351(5):497-500.

51. Lee CN, Deal AM, Huh R, et al. Quality of patient decisions about breast reconstruction after mastectomy. JAMA Surg. 2017;152(8):741-748.

52. Pinker K, Helbich TH, Morris EA. The potential of multiparametric MRI of the breast. Br J Radiol. 2017;90(1069):20160715.

53. Gillies RJ, Kinahan PE, Hricak H. Radiomics: images are more than pictures, they are data. Radiology. 2016;278(2):563-577.

54. Sutton EJ, Oh JH, Dashevsky BZ, Veeraraghavan H, Morris EA, Deasy JO. Breast cancer subtype intertumor heterogeneity: MRI-based features predict results of a genomic assay. Radiology. 2015;277(3):698-708.

55. Kuerer HM, Rauch GM, Krishnamurthy S, et al. A clinical feasibility trial for identification of exceptional responders in whom breast cancer surgery can be eliminated following neoadjuvant systemic therapy. Ann Surg. 2018;267(5):946-951.

56. Yamamoto S, Maki DD, Korn RL, Kuo MD. Radiogenomic analysis of breast cancer using MRI: a pilot study to define the landscape. Radiology. 2012;264(2):401-408.

57. Mango VL, Morris EA, Dershaw DD, et al. Abbreviated protocol for breast MRI: are multiple sequences needed for cancer detection? Eur J Radiol. 2015;84(1):65-70.