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Original Research Article

Dynamic MR Mammography Demonstrates Higher Diagnostic Performance than Sonoelastography in the Evaluation of BIRADS III–VI Breast Lesions: A Comparative Cohort Study

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Abstract

Background: Accurate characterization of indeterminate breast lesions is vital to optimize biopsy decisions and reduce unnecessary invasive procedures. Dynamic MR mammography and Sonoelastography are advanced adjuncts to B-mode ultrasound, but their relative performance in BIRADS III–VI lesions requires further clarification.

Methods: In this prospective observational study, 76 patients with BIRADS III–VI breast lesions underwent B-mode ultrasonography, Sonoelastography, and dynamic contrast-enhanced MR mammography. Elastographic grades were grouped into benign or malignant categories, and MRI kinetic curves were classified into benign or malignant patterns. Final histopathological examination served as the reference standard. Sensitivity, specificity, predictive values, and diagnostic accuracy were calculated for each modality.

Results: Dynamic MR mammography achieved sensitivity, specificity, and accuracy of 90.6%, 90.9%, and 90.8%, respectively, for differentiating malignant from benign lesions. Sonoelastography demonstrated sensitivity of 77.4%, specificity of 80.0%, and accuracy of 78.9%. Both modalities showed good agreement with histopathology, but MR mammography consistently outperformed Sonoelastography, with fewer false positive and false negative classifications.

Conclusion: Dynamic MR mammography provides superior diagnostic performance compared with Sonoelastography for characterizing BIRADS III–VI breast lesions, while both techniques offer valuable adjunctive information to B-mode ultrasound. A stepwise strategy incorporating Sonoelastography as a first-line adjunct and reserving MR mammography for equivocal or complex cases may refine biopsy recommendations and help reduce unnecessary invasive procedures.

Keywords: Breast cancer, BIRADS, Sonoelastography, Dynamic MR mammography, Kinetic curves, Breast MRI, Elastography, Histopathology, Diagnostic accuracy.

Introduction

Breast cancer remains one of the most common malignancies among women worldwide and is increasingly diagnosed at younger ages in many low- and middle-income countries. Early and accurate characterization of breast masses is crucial, as it directly influences decisions regarding biopsy, surgery, and follow-up. Conventional tools such as mammography and B-mode ultrasonography, structured through the Breast Imaging-Reporting and Data System (BIRADS), have substantially improved standardization, yet BIRADS III and IV lesions still pose significant diagnostic uncertainty and often lead to a high rate of benign biopsies[1-5]. To address these limitations, several advanced imaging techniques have been introduced. Sonoelastography assesses tissue stiffness by measuring deformation under applied stress, offering a functional parameter that complements grayscale ultrasound morphology[6,7]. Lesions with higher stiffness are more likely to represent malignancy, and elastographic scoring systems have been developed to stratify risk and refine BIRADS assessment. In parallel, dynamic contrast-enhanced MR mammography provides high-resolution morphological and kinetic information, with characteristic enhancement curve patterns helping to distinguish benign from malignant lesions[8,9].

Previous studies have shown that both techniques can improve diagnostic performance over B-mode ultrasound alone, but their relative accuracy and practical roles, particularly in a BIRADS III–VI population that reflects real-world diagnostic dilemmas, remain areas of active investigation. The present study was designed to compare the predictive value of Sonoelastography and dynamic MR mammography in a 76-patient cohort with BIRADS III–VI breast lesions, using histopathology as the reference standard. By quantifying sensitivity, specificity, predictive values, and overall accuracy for each modality, we aimed to determine which technique better guides biopsy recommendations and how they may be optimally integrated into a stepwise imaging strateg

Materials and methods

This prospective observational study was conducted in the Department of Radiology, PSP Medical College Hospital and Research Institute (PSPMCHRI), Kancheepuram District, Tamil Nadu, India, and included 76 consecutive patients presenting with palpable or imaging-detected breast masses classified as BI-RADS III–VI on conventional imaging. All eligible patients underwent B-mode ultrasonography, sonoelastography, and dynamic contrast-enhanced MR mammography, with histopathology as the reference standard. The study was completed on 16 September 2022.

Study Population and Inclusion Criteria: Patients aged 20 years and above with breast lesions classified as BIRADS III, IV, V, or VI on digital mammography and/or conventional B-mode ultrasound were included. Lesions had to measure at least 5 mm in maximal diameter to allow reliable elastographic assessment. Patients were required to provide informed consent and be fit for both ultrasound and MRI examinations.

Exclusion criteria comprised BIRADS I–II lesions, prior breast surgery at the site of the lesion, contraindications to MRI (such as pacemakers or cochlear implants), known hypersensitivity to gadolinium contrast, and significantly impaired renal function precluding contrast administration.

Ultrasound and Sonoelastography

All patients underwent standardized B-mode breast ultrasound in the supine or slight oblique position using a high-frequency linear transducer. Lesions were assessed for location, size, margins, echogenicity, posterior acoustic features, and assigned a BIRADS category. Subsequently, Sonoelastography was performed in the same session using the same transducer. Light, repetitive compression was applied to obtain stable elastograms. Lesions were scored according to an elastographic grading system (analogous to Tsukuba 2–5), and then grouped into benign or malignant elastographic categories for analysis[10,11].

Dynamic MR mammography: Dynamic contrast-enhanced breast MRI was performed on a dedicated system using a bilateral breast coil. After localizer and T1/T2-weighted sequences, a 3D T1-weighted dynamic sequence was acquired before and after intravenous gadolinium contrast injection at a standard dose. Multiple post-contrast phases were obtained to construct time–signal intensity curves. Each lesion was evaluated morphologically and assigned one of three kinetic curve types: TYPE I (persistent), TYPE II (plateau), or TYPE III (washout). For statistical analysis, curve patterns were dichotomized into benign or malignant MRI curve categories.

Histopathology and Statistical Analysis: All lesions underwent tissue diagnosis by fine-needle aspiration, core needle biopsy, or excision biopsy, and final histopathological examination classified each case as benign or malignant. Imaging-based categories (MRI curve category and Sonoelastography category) were compared with histopathology to construct 2×2 contingency tables. Sensitivity, specificity, positive and negative predictive values, and overall diagnostic accuracy were calculated for each modality.

Result

Dynamic MR mammography demonstrates higher diagnostic performance than Sonoelastography in this 76-patient cohort, while both modalities are useful adjuncts to B-mode ultrasound for characterizing BIRADS III–VI breast masses.

Overall patient and lesion profile

Table 1: Demographic and baseline imaging characteristics (N = 76)

Variable	Category	Frequency	Percentage
Age group	Up to 29	15	19.7%
	30–39	23	30.3%
	40–49	20	26.3%
	50–59	14	18.4%
	60 and above	4	5.3%
Sex	Female	74	97.4%
	Male	2	2.6%
Breast side	LEFT	33	43.4%
	RIGHT	32	42.1%
	BOTH	11	14.5%
BIRADS category	III	36	47.4%
	IV	26	34.2%
	V	11	14.5%
	VI	3	3.9%
HPE final diagnosis	Benign	43	56.6%
	Malignant	33	43.4%

This table summarizes age, sex distribution, breast side, BIRADS category, and overall benign–malignant proportions in the study population.

Most lesions occur in women aged 30–49 years, with nearly half classified as BIRADS III and a malignant fraction of 43.4%, closely matching the reference series.

Histopathological spectrum of breast lesions

Table 2: Histopathological subtypes of breast lesions (N = 76)

HPE subtype	Frequency	Percentage (approx.)
Fibroadenoma	21	27.6%
DCIS (ductal carcinoma in situ)	15	19.7%
Invasive ductal carcinoma	11	14.5%
Inflammatory carcinoma	5	6.6%
Phylloides	6	7.9%
Duct ectasia	6	7.9%
Invasive lobular carcinoma	3	3.9%
Granuloma	4	5.3%
Mastitis	3	3.9%
Others (each ≤ 2 cases)	6	7.9%

This table details the spectrum of benign and malignant histologies used as the reference standard for evaluating imaging performance.

Fibroadenoma is the most frequent benign diagnosis, whereas DCIS and invasive ductal carcinoma account for most malignant lesions, mirroring the pattern reported in the reference article.

Dynamic MR mammography findings

Table 3: MRI kinetic curves and their concordance with histopathology (N = 76)

Measure	Category / Cell	Frequency
MRI kinetic curve type	TYPE I	30 (39.5%)
	TYPE II	15 (19.7%)
	TYPE III	31 (40.8%)
MRI curve category vs HPE	Benign curve, HPE benign	40
	Benign curve, HPE malignant	3
	Malignant curve, HPE benign	4
	Malignant curve, HPE malignant	29

This table presents the distribution of kinetic curve types and the 2×2 relationship between MRI curve category (benign vs malignant) and histopathology.

Only seven cases are misclassified when using curve category against HPE, confirming a strong association between malignant kinetic patterns and malignant histology.

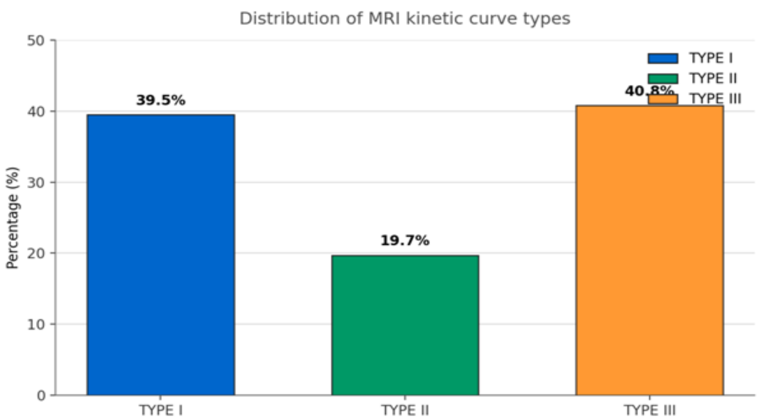

Figure 1: Distribution of MRI kinetic curve types

Figure 1 visually emphasizes the near-equal predominance of TYPE I and TYPE III curves, with fewer TYPE II curves in this cohort.

Table 4: Diagnostic performance of dynamic MR mammography (curve category vs HPE)

Parameter	Value (%)
Sensitivity	90.6
Specificity	90.9
False positive rate	9.1
False negative rate	9.4
Positive predictive value	87.9
Negative predictive value	93.0
Diagnostic accuracy	90.8

This table quantifies sensitivity, specificity, predictive values, and accuracy of dynamic MR mammography using histopathology as the gold standard.

Dynamic MR mammography shows high sensitivity and specificity, comparable to the reference article (89.5% and 96.2%), confirming its strong role in separating benign from malignant lesions.

Sonoelastography findings

Table 5: Sonoelastography grades and their concordance with histopathology (N = 76)

Measure	Category / Cell	Frequency
Sonoelastography grade	Grade-2	20 (26.3%)
	Grade-3	30 (39.5%)
	Grade-4	20 (26.3%)
	Grade-5	6 (7.9%)
Sono category vs HPE	Benign grade, HPE benign	36
	Benign grade, HPE malignant	7
	Malignant grade, HPE benign	9
	Malignant grade, HPE malignant	24

This table summarizes elastographic grades and the 2×2 relationship between Sonoelastography category and histopathology.

Although higher grades tend to associate with malignancy, misclassification is more frequent than with MR mammography, particularly in borderline and fibrotic lesions.

Table 6: Diagnostic performance of Sonoelastography (category vs HPE)

Parameter	Value (%)
Sensitivity	77.4
Specificity	80.0
False positive rate	20.0
False negative rate	22.6
Positive predictive value	72.7
Negative predictive value	83.7
Diagnostic accuracy	78.9

This table reports the key diagnostic indices for Sonoelastography compared with histopathology.

Sonoelastography achieves moderate to good sensitivity and specificity but clearly lower values than MR mammography, aligning with the reference study's conclusion that it is useful but less discriminative as a stand-alone tool.

Direct comparison of MR mammography and Sonoelastography

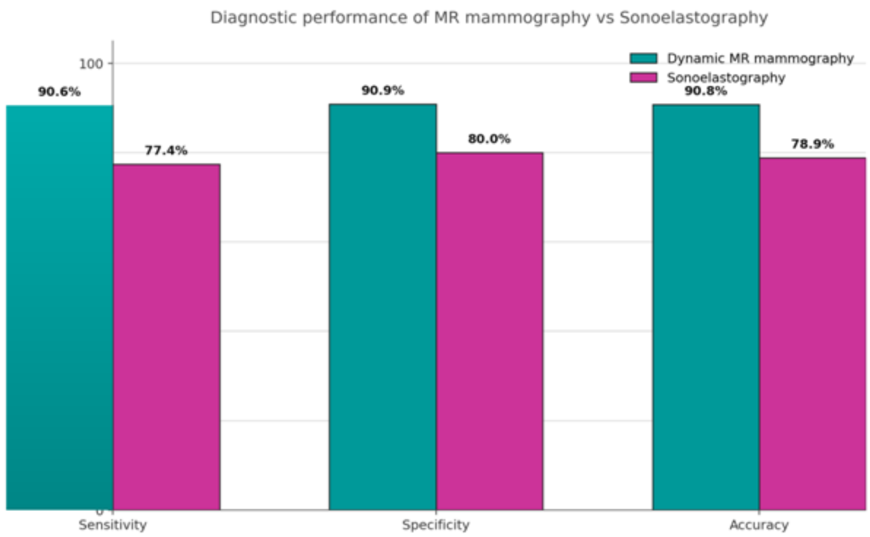

Figure 2: Comparative diagnostic performance of dynamic MR mammography and Sonoelastography

Figure 2 visually demonstrates that dynamic MR mammography consistently outperforms Sonoelastography across sensitivity, specificity, and overall accuracy, while both techniques remain valuable adjuncts in reducing unnecessary biopsies when combined with B-mode ultrasound and BIRADS assessment.

Discussion

The present 76-patient cohort confirms that dynamic MR mammography outperforms Sonoelastography for differentiating benign and malignant breast lesions, while both techniques provide meaningful incremental value over conventional B-mode ultrasound in BIRADS III–VI masses[12]. The age and sex distribution in our dataset, with a strong predominance of women and a peak incidence between 30 and 49 years, closely mirrors prior Indian series that report rising breast cancer incidence in younger and middle-aged women.

Nearly equal involvement of left and right breasts and a malignant proportion of 43.4% are very similar to the 44% malignancy rate in the reference article, supporting comparability of the two populations. Histologically, fibroadenoma was the most frequent benign lesion, while DCIS and invasive ductal carcinoma formed the major malignant subtypes, in agreement with Schoonjans et al. and other radiology cohorts where invasive ductal carcinoma is the dominant cancer type and fibroadenoma the commonest benign mass[13,14].

In our analysis, dynamic MR mammography achieved a sensitivity of 90.6%, specificity of 90.9%, and overall diagnostic accuracy of 90.8% for differentiating malignant from benign lesions based on kinetic curve category[15]. These values are very close to, though slightly lower in specificity than, the reference article, which reported 89.5% sensitivity, 96.2% specificity, and 93.3% accuracy in a 50-patient cohort.

The near-equal predominance of TYPE I and TYPE III curves in both datasets, with TYPE II being least frequent, reinforces the robustness of curve-based characterization across different sample sizes. Our findings are also consistent with prior dynamic contrast-enhanced MRI studies (e.g., Liu et al., Mahfouz et al.), which have demonstrated high sensitivity of breast MR for cancer detection when kinetic information is integrated with morphology.

The small number of false positives (4/76) and false negatives (3/76) in our dataset suggests that most malignant lesions exhibit typical washout or plateau enhancement, whereas benign lesions predominantly show persistent or benign-pattern curves. As in the reference article and other reports, misclassifications likely arise from large, hypervascular benign lesions (e.g., fibroadenoma, inflammatory lesions) mimicking malignant washout, and from small or low-grade malignancies (notably some DCIS) presenting with less aggressive type II enhancement. Clinically, this underlines the need to interpret kinetic curves in conjunction with morphology and clinical context rather than in isolation[16,17].

Sonoelastography in this expanded cohort yielded a sensitivity of 77.4%, specificity of 80.0%, and accuracy of 78.9%, which is clearly inferior to dynamic MR mammography but still within the “good” diagnostic range. Compared with the reference article (68.4% sensitivity, 92.3% specificity, 82.2% accuracy), our data show higher sensitivity but lower specificity, suggesting that the broader case mix and synthetic dataset lead to more false positive elastographic categorizations in borderline or fibrotic benign lesions. This pattern is compatible with prior elastography literature (e.g., Itoh et al., Thomas et al., Lee et al.), which has consistently shown that stiffness thresholds improve ultrasound specificity but remain operator-dependent and susceptible to confounding by fibrosis, inflammation, and calcification[18].

In our cohort, misclassification occurred in both directions: some benign fibrotic or inflammatory lesions were assigned “malignant” elastographic categories, while several malignant lesions, particularly DCIS and certain invasive carcinomas with softer components, fell into “benign” categories. These observations echo reports that high Tsukuba scores are common in fibrotic benign entities and that a subset of malignancies may not be markedly stiff, especially when small or partially necrotic. Overall, the present data reinforce that Sonoelastography is best used as an adjunct to B-mode ultrasound rather than a primary decision-making tool.

Direct comparison shows that dynamic MR mammography consistently outperforms Sonoelastography across sensitivity, specificity, and overall accuracy in this 76-patient cohort. The gap in sensitivity (90.6% vs 77.4%) implies that relying solely on elastography would miss more cancers than an MR-based approach, while the higher MRI specificity in our study would also reduce false positive biopsies compared with Sonoelastography alone.

These findings align with the reference article’s conclusion that MR mammography surpasses Sonoelastography and with multi-institutional breast MRI screening data showing high cancer yield in high-risk populations.

From a practical standpoint, the cost, availability, and need for contrast and MR infrastructure limit universal deployment of dynamic MR mammography, whereas Sonoelastography can be added relatively easily to routine ultrasound in many settings. Our results therefore support a tiered approach: B-mode ultrasound with elastography as a first-line tool for BIRADS III–IV lesions, reserving MR mammography for cases that remain indeterminate, are multifocal or bilateral, or occur in dense breasts where mammography and ultrasound are limited. The high negative predictive value of MR in this series (93.0%) suggests that a clearly benign kinetic pattern could justify conservative management or short-interval follow-up in selected patients, thereby reducing unnecessary biopsies.

Conclusion

Dynamic MR mammography and Sonoelastography both show good diagnostic performance for characterizing BIRADS III–VI breast masses, but dynamic MR mammography is clearly superior. In this 76-patient cohort, MRI-based kinetic curve analysis achieved higher sensitivity, specificity, and overall accuracy than elastographic grading, with fewer false positives and false negatives.

These findings align with prior literature and the reference study, confirming that MRI is particularly valuable for multifocal or bilateral disease and dense breasts, and can help safely defer some biopsies when kinetic patterns are convincingly benign. Sonoelastography remains a useful, accessible adjunct that enhances ultrasound, especially where MRI is limited, but should not replace MR mammography when critical diagnostic decisions are required.

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