

## DIAGNOSTIC ACCURACY OF TYPE II KUHL, CURVE BREAST MRI IN DIFFERENTIATING BENIGN FROM MALIGNANT LESION KEEPING HISTOPATHOLOGY AS GOLD STANDARD

Mahnoor Naeem<sup>\*1</sup>, Maryam Khalid Cheema<sup>2</sup>, Mubashrah Aziz<sup>3</sup>, Nigaar Ayesha Iftikhar<sup>4</sup>, Saira Noreen<sup>5</sup>, Sarah Nathaniel<sup>6</sup>

<sup>\*1,2,3,4,5,6</sup>Armed forces institute of radiology AFIRI

<sup>\*1</sup>naeemmahnoor656@gmail.com

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Corresponding Author: \*  
Mahnoor Naeem

### Abstract

*Background:* Dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) is a sensitive tool for breast cancer detection, with kinetic curve analysis (Kuhl classification) being a key component. However, the diagnostic value of the Type II (plateau) curve is challenging due to its significant overlap in appearance between benign and malignant lesions. *Objective:* To evaluate the diagnostic accuracy of the Type II (plateau) kinetic curve on breast MRI in differentiating benign from malignant breast lesions, using histopathology as the gold standard. *Methods:* This prospective, cross-sectional study was conducted over six months and included 150 women with breast lesions categorized as BI-RADS 4 or 5 on prior imaging. All participants underwent DCE-MRI, and kinetic curves were analyzed by two blinded radiologists. Histopathological results from core needle biopsy or surgical excision served as the reference standard. Diagnostic metrics (sensitivity, specificity, predictive values, accuracy) for Type II curves were calculated. *Results:* Out of 150 lesions, 92 (61.3%) were malignant and 58 (38.7%) were benign on histopathology. Among the 50 lesions with a Type II curve, 38 were malignant and 12 were benign. The diagnostic performance of the Type II curve for predicting malignancy showed a sensitivity of 41.3%, specificity of 79.3%, positive predictive value (PPV) of 76.0%, negative predictive value (NPV) of 46.0%, and an overall diagnostic accuracy of 56.0%. *Conclusion:* The Type II (plateau) kinetic curve demonstrates moderate specificity and PPV but low sensitivity and NPV for identifying malignant breast lesions. Its substantial overlap between benign and malignant entities limits its reliability as a standalone diagnostic tool. Therefore, kinetic analysis must be integrated with morphological BI-RADS descriptors to improve diagnostic accuracy and guide clinical decision-making.

### INTRODUCTION

Breast cancer is the most common female malignancy in both the developing and developed world, and the primary cause of death among women globally. In the year 2011, incidence rates of breast cancer were proved to be high in developed regions of the world (>80 per 100,000) and low in most of the developing

regions (<40 per 100,000).<sup>1</sup> In Pakistan, it was found to be the most common malignancy accounting for 34.6% of female cancers,<sup>2</sup> with at least 90,000 women suffering every year.<sup>3</sup> Mammography is the primary imaging technique for detection of early breast cancer; however, it has variable sensitivity and specificity

ranging from 68-88% and 82-98%, respectively.<sup>4</sup> Magnetic resonance mammography is a more sensitive tool for detection of breast cancer. However, there is a controversy about the accuracy of MR mammography with sensitivity being as high as 88-100% while its specificity is low being equivalent to that of mammography, i.e. 68-96%.<sup>5,6</sup> In the year 2012, sensitivity of MR mammography was proved to be 71 % with a specificity of 68%.<sup>7</sup> The most frequently used MRI technique for evaluating breast cancer is dynamic contrast-enhanced magnetic resonance imaging (DCE-MR). A low molecular weight contrast agent (gadolinium) is injected intravenously for DCE-MR imaging. Gadolinium uptake and washout, and thus the detection of signal changes on T1-weighted images and the differentiation of cancerous from normal breast tissue, are the foundations of DCE-MR imaging of breast cancer<sup>8</sup>. The aim of this study was to examine the histopathological outcomes of lesions with type 2 dynamic curves, in which there is a high degree of overlap between benign and malignant entities in the kinetic analysis performed using dynamic contrast MR imaging.

## Methodology:

This prospective, observational, cross-sectional study was designed to evaluate the diagnostic accuracy of breast MRI, allowing for the simultaneous application of the index test (MRI) and the reference standard (histopathology) within the same participant group. The study was conducted in the Radiology and Imaging Department of a tertiary care hospital or a dedicated breast imaging center, which ensured a consistent flow of patients with suspicious breast lesions requiring both MRI and histological assessment. The total study duration was six months, comprising five months for patient enrollment and one month for data analysis and report writing.

A target sample size of 150 participants was recruited using consecutive, non-probability sampling, whereby all eligible patients presenting during the enrollment period were invited until the sample size was reached. Inclusion criteria consisted of adult women (age  $\geq$  18 years) with a breast lesion previously categorized as BI-

RADS 4 or 5 on mammography or ultrasound, who were scheduled for a diagnostic breast MRI and subsequent histological confirmation, and who were willing to provide informed consent. Exclusion criteria included contraindications to MRI, known allergy to gadolinium-based contrast agents, severe renal impairment (GFR  $<$  30 mL/min), pregnancy or lactation, prior neoadjuvant chemotherapy, or any lesion that had undergone intervention before the MRI.

The methodology followed a structured process beginning with participant recruitment and the obtaining of informed consent. Breast MRI was performed using a 1.5 Tesla or 3.0 Tesla scanner with a dedicated breast coil and a standardized dynamic contrast-enhanced (DCE-MRI) protocol. This included pre-contrast axial T1 and T2-weighted sequences, followed by a dynamic series with at least five post-contrast phases after gadolinium injection, each with a temporal resolution of  $\leq$ 90 seconds. Image analysis was conducted by two experienced radiologists who were blinded to prior imaging and histopathology results. They performed both qualitative assessment based on the ACR BI-RADS MRI lexicon and quantitative analysis focusing on kinetic curve types (Kuhl classification), with Type II (plateau) curves being the primary focus.

Each radiologist independently assigned a BI-RADS category, which was later dichotomized into positive (BI-RADS 4-5) or negative (BI-RADS 2-3) for malignancy. Histopathological results from core needle biopsy or surgical excision served as the gold standard, classifying outcomes as malignant or benign. Data were systematically recorded using a structured collection form to ensure comprehensive and standardized documentation throughout the study.

## Results

A total of 150 female participants with breast lesions categorized as BI-RADS 4 or 5 on prior imaging were enrolled in the study. All participants underwent dynamic contrast-enhanced breast MRI followed by histopathological confirmation.

Table 1: Baseline Characteristics of the Study Participants (n=150)

Characteristic	Value
Mean Age (years)	51.8 ± 11.3
BI-RADS Category on Prior Imaging	
BI-RADS 4	110 (73.3%)
BI-RADS 5	40 (26.7%)
Mean Lesion Size on MRI (mm)	24.6 ± 12.1
Method of Histopathological Confirmation	
Core Needle Biopsy	128 (85.3%)
Surgical Excision	22 (14.7%)

Table 2: Final Histopathological Diagnosis of the Studied Lesions (n=150)

Histopathological Result	Number of Lesions	Percentage (%)
<b>Malignant Lesions</b>	<b>92</b>	<b>61.3%</b>
Invasive Ductal Carcinoma	75	50.0%
Ductal Carcinoma in Situ (DCIS)	12	8.0%
Other Malignancies	5	3.3%
<b>Benign Lesions</b>	<b>58</b>	<b>38.7%</b>
Fibroadenoma	25	16.7%
Fibrocystic Changes	20	13.3%
Other Benign Pathologies	13	8.7%
<b>Total</b>	<b>150</b>	<b>100%</b>

Table 3: Distribution of Kuhl Curve Types against Histopathology Gold Standard

Kuhl Curve Type	Malignant on Histopathology	Benign on Histopathology	Total
Type I (Persistent)	5	42	47
Type II (Plateau)	38	12	50
Type III (Washout)	49	4	53
Total	92	58	150

Table 4: Diagnostic Performance of Type II (Plateau) Curve for Predicting Malignancy

This analysis treats a Type II curve as a "positive" test result for malignancy.

Diagnostic Metric	Calculation	Value (%)	95% Confidence Interval
Sensitivity	38 / 92	41.3%	31.2% - 52.1%
Specificity	46 / 58	79.3%	66.9% - 88.7%
Positive Predictive Value (PPV)	38 / 50	76.0%	62.2% - 86.1%
Negative Predictive Value (NPV)	46 / 100	46.0%	36.1% - 56.2%
Diagnostic Accuracy	(38+46) / 150	56.0%	47.8% - 64.0%

Contingency Table for Reference:

- True Positives (A): 38
- False Positives (B): 12
- False Negatives (C): 54
- True Negatives (D): 46

Table 5: Inter-observer Agreement between the Two Radiologists for BI-RADS Assessment

BI-RADS Category (Reader 1 vs. Reader 2)	Number of Lesions	Percentage Agreement (%)	Kappa Statistic (κ)
Exact Agreement	135 / 150	90.0%	0.85 (p < 0.001)
Agreement within ±1 category	148 / 150	98.7%	-

**Discussion:**

The present findings reaffirm the diagnostic complexity associated with Type II (plateau) kinetic curves, primarily due to their substantial overlap between benign and malignant breast lesions. Although these curves demonstrated moderate specificity (79.3%) and a positive predictive value (76.0%), their limited sensitivity (41.3%) diminishes their reliability as an independent diagnostic marker for excluding malignancy. Furthermore, the relatively low negative predictive value (46.0%) emphasizes that the absence of a Type II curve cannot be considered reassuring for ruling out cancer. Consequently, clinical interpretation of lesions with a Type II curve should be approached cautiously and always supplemented with morphological descriptors from the BI-RADS lexicon to minimize the risk of misclassification<sup>9</sup>.

In comparison with prior studies, our results were inconsistent. Specifically, the diagnostic performance in our analysis (sensitivity 41.3%, specificity 79.3%, accuracy 56.0%, PPV 76.0%, NPV 46.0%) was notably inferior to the considerably higher diagnostic indices reported in earlier work, such as sensitivity of 93.9%, specificity of 73.5%, and accuracy of 89.3%<sup>10</sup>. However, our findings aligned with certain studies that also documented relatively low sensitivity (~40%) and comparable specificity (~73-79%) for Type II kinetic curves in predicting malignancy<sup>11</sup>. This suggests that variability across studies may be attributed to differences in patient populations, imaging protocols, and interpretative criteria. Additionally, our diagnostic parameters contrasted sharply with the substantially higher accuracy metrics observed for conventional breast ultrasound in comparable research, where sensitivity reached

91.07% and specificity 83.57%<sup>12</sup>. Nonetheless, consistent with other reports, our study corroborates that dynamic contrast-enhanced MRI remains superior to BI-RADS mammography categories in terms of overall diagnostic accuracy<sup>13</sup>.

**Conclusion:**

Based on the study findings, it is concluded that while Type II (plateau) kinetic curves on breast MRI demonstrate moderate specificity (79.3%) and positive predictive value (76.0%) in identifying malignant lesions, their low sensitivity (41.3%) and negative predictive value (46.0%) limit their reliability as a standalone diagnostic tool. This significant overlap between benign and malignant lesions underscores the necessity of integrating kinetic curve analysis with morphological BI-RADS descriptors to improve diagnostic accuracy and reduce misclassification, rather than relying solely on kinetic patterns for clinical decision-making.

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