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Original Research Article

Histopathological Correlation of Time Signal Intensity Curve in MRI Detected Breast Lesions

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ABSTRACT

Introduction: Dynamic contrast enhanced MR imaging of breast characterizes the lesions more accurately than morphological parameters which helps in to distinguish between benign and malignant lesions.

Aims: To differentiate benign from malignant breast lesions detected on MRI by analyzing quantitative lesion characteristics. To compare and correlate the radiological diagnosis with the final histopathological diagnosis.

Materials and Methods: A prospective study on 41 cases was conducted in the department of Radiodiagnosis, Government Medical College, Kozhikode during the period from Aug 2009 to July 2010 who were undergoing MRI of breast for characterization of lesions. Contrast enhancement Initial and post initial kinetics were plotted on a graph to get the time signal intensity curve which was studied and correlated with the final histopathological diagnosis.

Results: Of the total 41 cases, 48.8% were malignant and 51.2% were benign. 38.1% of the benign lesions showed <50% initial enhancement while no malignant lesions showed this. 80% of malignancies demonstrated strong (>100%) initial enhancement. 20% of malignant lesions and 28.6% of benign lesions demonstrated moderate (50-100%) initial enhancement. Continuous post initial kinetics was noted in 66.7% of benign lesions and none of the malignant lesions. 95% of malignancies showed washout kinetics. Plateau kinetics was shown by 5% of malignant and 9.5% of benign lesions

Conclusion: Malignant lesions more frequently showed >100% initial kinetics and type III (wash out) post initial kinetics; however, an overlap exists.

Keywords: Breast MRI, Breast Lesion, Time Signal Intensity Curve, Initial Kinetics, Post Initial Kinetics, Benign, Malignant.

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INTRODUCTION

Contrast enhanced MR imaging of breast characterizes the lesions more accurately than mammography or sonography. Dynamic contrast enhanced MR imaging of breast lesions characterizes the lesions more accurately than morphological parameters which helps in to distinguish between benign and malignant lesions.

AIMS AND OBJECTIVES

1. To differentiate benign from malignant breast lesions that had been detected on MR imaging by analyzing its contarst enhancement initial and post initial kinetics.
2. To compare and correlate the radiological diagnosis with the final histopathological diagnosis

MATERIALS AND METHODS

Study Design

Diagnostic test evaluation

Study Setting

All patients undergoing MR imaging of breast at Department of Radiodiagnosis, Govt. Medical College, Kozhikode for characterization of breast lesions detected clinically, by x-ray mammography or by ultrasonography.

Study Period

August 2009 to July 2010

Study Method

41 cases of breast lesions were evaluated with MRI.

Dynamic parameters like contrast enhancement initial and post initial kinetics studied and plotted on a graph to get the time signal intensity curve which was studied and correlated with the final histopathological diagnosis. Final histopathological report of all the lesions were compared and correlated with MRI findings

The following criteria's were evaluated.

Kinetic data was evaluated by visually assessing the lesion enhancement pattern by placing a region of interest to obtain

kinetic curves and by using a computer aided detector system. ROIs placed with wide window settings into the area that exhibits strongest enhancement on the first post contrast image.[1] Enhancement dynamics describes the signal intensity changes occurring in a contrast enhancing region with respect to time.[2] To quantify enhancement, the increase in signal intensity relative to base line pre contrast signal intensity is measured.[1] The initial signal increase (in %) is the maximum signal intensity within the first 2 minutes after contrast medium administration compared to signal intensity of the pre contrast image. It is calculated using the formula.[2]

Initial Signal Increase (%) =

$$\frac{\text{Signal (post cm)} - \text{Signal (pre cm)}}{\text{Signal (pre cm)}} \times 100$$

[cm = contrast measurement]

Initial Signal Increase

None to slight: Less than 50% increase in signal intensity compared to pre contrast measurement.

Moderate: Between 50% and 100% increase in signal intensity compared to pre contrast measurement.

Strong: Over 100% increase in signal intensity compared to pre contrast measurement.

Post Initial Signal Behaviour[2]

This describes the course of signal curve between 2-8 minutes after contrast administration.

Post initial signal behaviour =

$$\frac{\text{Signal (8mts)-Signal (max 1 – 2 mts)}}{\text{Signal (max1-2mts)}} \times 100\%$$

Three types of time signal intensity curves have been described.[3,4]

(i) Type I (Continuous): Signal increase over 10%

(ii) Type II (Plateau): Constant signal intensity (+/- 10%)

(iii) Type III (Washout): Signal decrease over 10%

Sample Size

41 patients

All patients satisfying inclusion criteria were included in the study.

Inclusion Criteria

a) Patients with inconclusive study by mammogram or ultrasound.
b) Those which have biopsy proven malignancy.
c) Those which have cytology proven malignancy with benign appearance of lesion by mammogram or ultrasound.
d) Post-operative or post chemotherapy patients to know residual disease.
e) Those with occult carcinoma with breast primary in axillary lymph node

Exclusion Criteria

1. Patients under hormone therapy
2. Patients in luteal phase of menstrual cycle
3. Patients with contraindication for MRI.

MRI Protocols and Imaging (Technique Used)

MRI was performed on a 1.5 T commercial available system (signaHDxT, General Electric Health care), bilateral 8 channel phased array breast coil. Images were acquired with the patient in prone position and with both breasts imaged simultaneously & the following sequences were performed.

(a) Pre contrast T1 weighted fat suppressed 3D fast spoiled gradient echo
(b) Post contrast T1 W axial dynamic study after a rapid bolus injection of gadopentetate dimeglumine (0.I mmol/kg of body weight) delivered through an indwelling IV catheter followed by 10ml saline bolus infusion.; the comprehensive dynamic protocol consisted of fast dynamic imaging in the first 45 seconds followed by slow dynamic imaging in 6 consecutive series at 78 seconds intervals.

After the examination, the unenhanced images were subtracted from the first enhanced images on a pixel by pixel basis.

Statistical Analysis

Statistical analysis was performed using computerized statistics software (Epi- Info, centres for Disease control and prevention, Atlanta, GA) with the Chi-square and Fischer's exact tests.

Sensitivity, specificity and associated statistics were worked out and provided.

Figure 1: Distribution according to contrast enhancement-initial kinetics

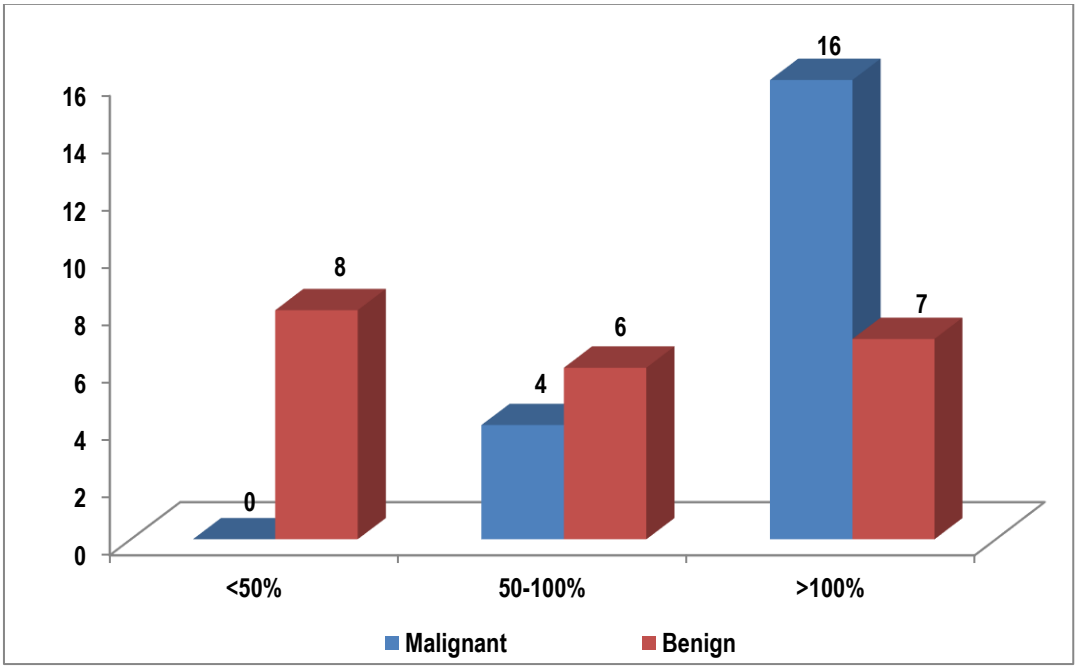


Figure 2: Distribution according to post initial kinetics

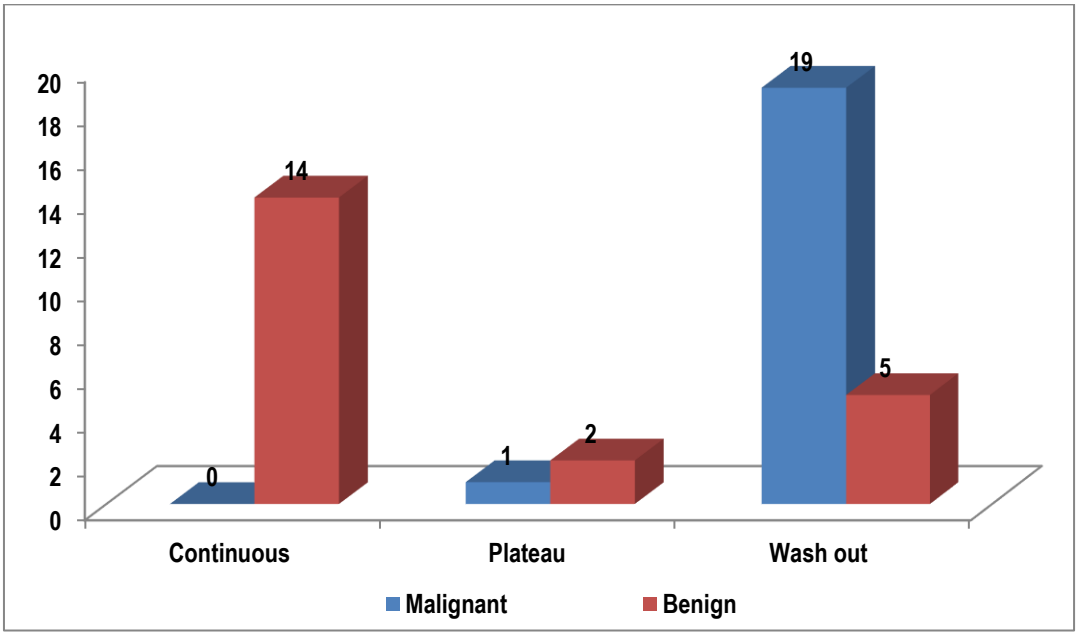


Table 1: Frequency distribution of initial kinetics <50%

Test results	Gold standard diagnosis		Total
	Malignant	Benign	
Positive	0	8	8
Negative	20	13	33
Total	20	21	41

Table 2: Statistical indices of initial kinetics <50%

Sensitivity	0%
Specificity	62%
Positive predictive value	0%
Negative predictive value	39%

Table 3: Frequency distribution of initial kinetics 50-100%

Test results	Gold standard diagnosis		Total
	Malignant	Benign	
Positive	4	6	10
Negative	16	15	31
Total	20	21	41

Table 4: Statistical indices of initial kinetics 50-100%

Sensitivity	20%
Specificity	71%
Positive predictive value	40%
Negative predictive value	48%

Table 5: Frequency distribution of initial kinetics >100%

Test results	Gold standard diagnosis		Total
	Malignant	Benign	
Positive	16	7	23
Negative	4	14	18
Total	20	21	41

Table 6: Statistical indices of initial kinetics >100%

Sensitivity	80%
Specificity	67%
Positive predictive value	70%
Negative predictive value	78%

Table 7: Frequency distribution of type I curve

Test results	Gold standard diagnosis		Total
	Malignant	Benign	
Positive	0	14	14
Negative	20	7	27
Total	20	21	41

Table 8: Statistical indices of type I curve

Sensitivity	**0%**
Specificity	33%
Positive predictive value	0%
Negative predictive value	26%

Table 9: Frequency distribution of type II curve

Test results	Gold standard diagnosis		Total
	Malignant	Benign	
Positive	1	2	3
Negative	19	19	38
Total	20	21	41

Table 10: Statistical indices of type II curve

Sensitivity	**5%**
Specificity	90%
Positive predictive value	33%
Negative predictive value	50%

Table 11: Frequency distribution of type III curve

Test results	Gold standard diagnosis		Total
	Malignant	Benign	
Positive	19	5	24
Negative	1	16	17
Total	20	21	41

Table 12: Statistical indices of type III curve

Sensitivity	**95%**
Specificity	76%
Positive predictive value	79%
Negative predictive value	94%

RESULTS

Of the total 21 benign lesions, <50% initial enhancement was observed in 38.1% while no malignant lesions showed this. Significant percentage (80%) of malignancies demonstrated strong (>100%) initial enhancement. 20% of malignant lesions and 28.6% of benign lesions demonstrated moderate (50-100%) initial enhancement. Continuous post initial kinetics was noted in 66.7% of benign lesions and none of the malignant lesions. 95% of malignancies showed washout kinetics. Plateau kinetics was shown by 5% of malignant and 9.5% of benign lesions.

Out of the four atypical ductal hyperplasia cases equal distribution was noted between moderate (50-100%) and strong (>100%) initial kinetics, also a similar pattern was observed in post initial dynamics (two showed plateau and two showed wash out curve).

Of the three papillomas, all showed type III (wash out) post initial kinetics with two showing >100% initial kinetics and one showing 50-100% initial kinetics. All the two sclerosing adenosis without atypia showed type I (continuous) post initial kinetics with both of them showing rapid initial enhancement. All the inflammatory changes (six) showed type I (continuous) post initial kinetics with four (66.6%) showing <50% and two (33.3%) showing 50-100% initial kinetics.

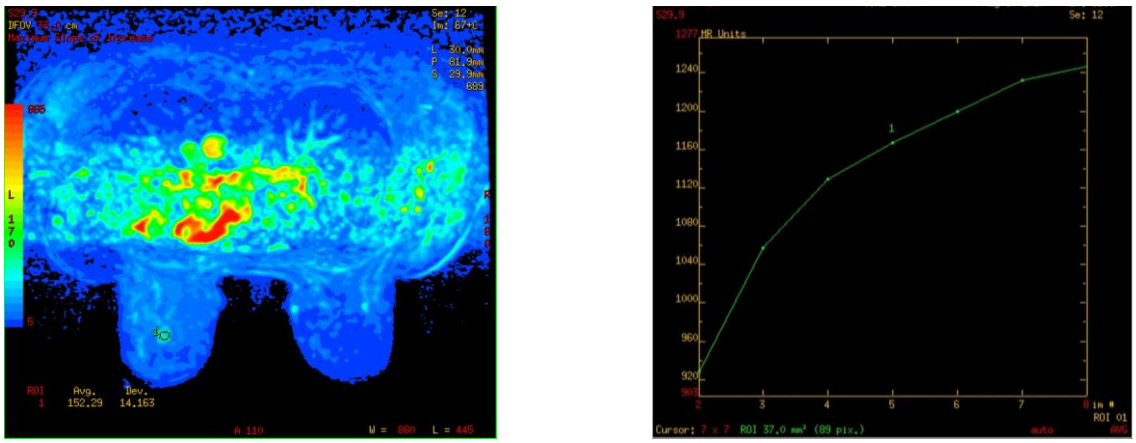
DISCUSSION AND CONCLUSIONS

Initial Dynamics

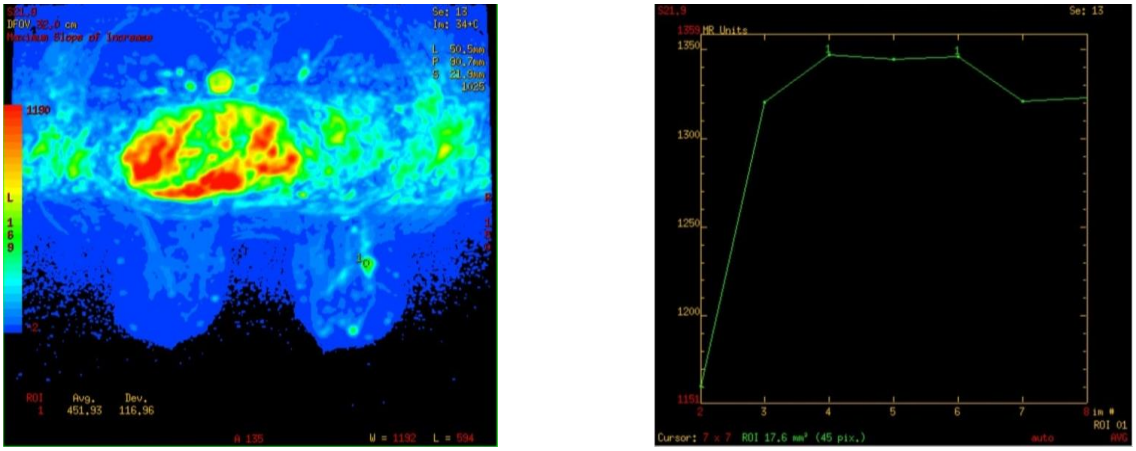
In this study, of the total 21 benign cases, <50% initial enhancement was observed in 38.1% while no malignant lesions showed this. Significant percentage (80%) of malignancies demonstrated strong (>100%) initial enhancement. 20% of malignant lesions and 28.6% of benign lesions demonstrated 50-100% initial enhancement.

Schnall et al[5] concluded that the quantitative features most indicative of cancer were the maximum enhancement rate and the percentage of enhancement at 1 minute with rapid enhancement being characteristic of a malignancy which is well correlating with the present study. Siegmann et al[6] proposed that malignant lesions showed a higher maximum slope of the enhancement curve, reached the mean signal intensity peak earlier. Nevertheless there exists a considerable overlap. Kuhl et al[3] found that there was a considerable overlap in the range of enhancement rates of benign and malignant lesions with a reported sensitivity of 91%, a specificity of 37%, a positive predictive value of 47% and a NPV of 87%. The study observed that significant number (95%) of malignant lesions showed washout curve even though overlap existed. This correlates with

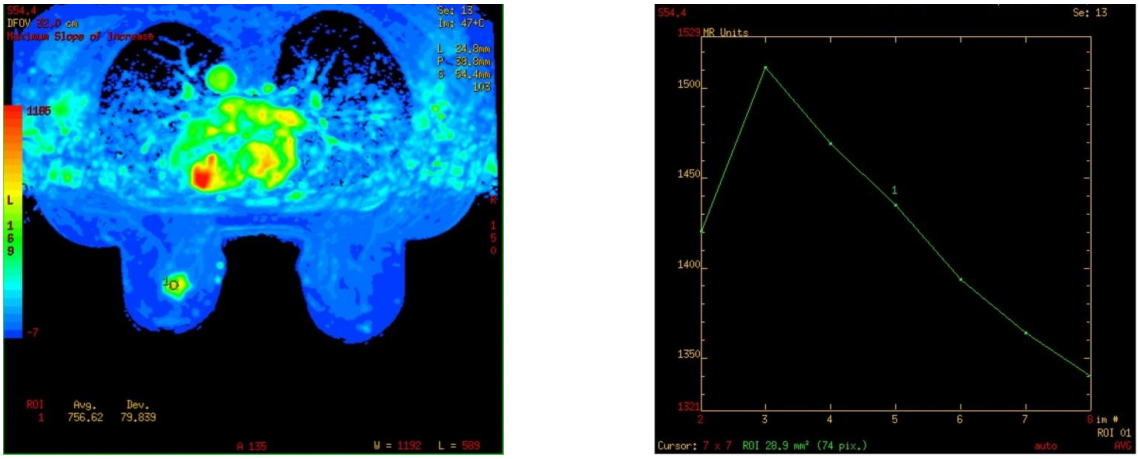
the study by Siegmann et al[6] who concluded that malignant lesions showed a stronger loss of enhancement (wash out) from the initial signal intensity peak to the last contrast enhanced measurement. Nevertheless there exists a considerable overlap.



Case 1: Color coded map of the enhancing lesion in left breast with time signal intensity curve showing type I curve. HPR-Fibroadenoma



Case 2: Color coded map of the enhancing lesion in right breast with time signal intensity curve showing type II curve. HPR-Atypical ductal hyperplasia



Case 3: Color coded map of the enhancing lesion in left breast with time signal intensity curve showing type III curve. HPR- Invasive ductal carcinoma with ductal carcinoma in situ

Table 13: Post initial dynamics – Percentage distribution among benign and malignant lesions

	Type I curve		Type III curve	
	Benign	**Malignant**	**Benign**	**Malignant**
Schnall et al[5]	45%			76%
Kuhl et al[3]	83%			57%
Liberman et al[7]				33%
Present study	66.7%	0%	23.8%	95%

The present study reports that 23.8% of benign lesions demonstrated washout curve. This disparity may be explained by the histologic variety of the lesions in this study. Benign lesions like sclerosing adenosis, atypical ductal hyperplasia, papillomas and young fibroadenomas showed washout kinetics.

Kuhl et al[3] reported that 83% of the benign lesion exhibited a steady continuous time signal intensity curve compared to 66.7% in the present study.

Liberman et al[7] found that the most common pattern was plateau present in 64%. Carcinoma was present in 33% of the lesions that showed wash out versus 24% of the lesions that had other kinetic patterns. Infiltrating carcinoma was present in 29% of the lesions with wash out versus 6% of the lesions without wash out.

In this study, atypical ductal hyperplasia and papillomas demonstrated features favouring malignancy.

In papillomas the study observed malignant quantitative features like wash out kinetics (100%) and rapid initial enhancement (66.6%). In contrast, 50% of sclerosing adenosis without atypia showed benign post initial kinetics which is correlating with previous studies[8]. On reviewing pathology literatures[9-11], both papillomas and atypical ductal hyperplasia have got an increased relative risk for subsequent development of malignancies.

Table 14: Features of malignancy in benign lesions in the present study

	Atypical ductal hyperplasia	Papilloma	Sclerosing adenosis without atypia
Wash out kinetics	50% (n=2)	100% (n=3)	0%

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