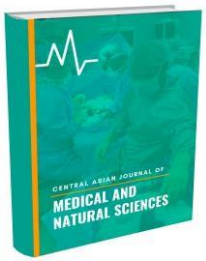

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Article

Optimizing ADC Values for Distinguishing Between Benign and Malignant Breast Lesions

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Abstract: The review was a cross-sectional survey of breast lesions in ladies from Al-Imam Al-Hussein Teaching Hospital, Nasiriyah, Iraq, directed between April 2022 and July 2023. The patients were examined with ultrasound and mammogram and went through MRI evaluations utilizing a 1.5 Tesla MR unit. The outcomes were assessed as per the American School of Radiology BI-RADS breast imaging dictionary. A sum of 38 patients were remembered for the review, with a sum of 46 injuries. All lesions went through histopathological findings, which was viewed as the best quality level for the review. The ideal cutoff value was $<1.232x10^{-3}$ mm^2/s, displaying a sensitivity of 100 percent, specificity of 90%, a positive predictive value (PPV) of 92%, a negative predictive value (NPV) of 100 percent, and an accuracy rate of 95.7%. The DCE-MRI exhibited a sensitivity of 96%, a specificity of 85%, a positive predictive value (PPV) of 89%, a negative predictive value (NPV) of 94%, and an accuracy rate of 91.3%. The combined examination of a contrast-enhanced DCE-MRI and diffusion-weighted imaging (DWI) brought about an increment of 4% in the sensitivity and the specificity by 10 %. The addition of DWI to the standard breast MRI has a sensitivity of 100%, a specificity of 95%, a positive predictive value (PPV) of 96%, a negative predictive value (NPV) of 100%, and an accuracy rate of 97.8%. These outcomes show that DWI is an important instrument for portraying breast lesions.

Keywords: Breast lesions, Diagnostic, DWI, NPV, Sensitivity, DCE-MRI, PPV, Benign, Malignant

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1. Introduction

MRI is essential for detecting breast cancer at an early stage in patients who do not show any symptoms, hence decreasing mortality rates [1, 2]. It is advisable to use this method for detecting breast issues, assessing breast lumps, and monitoring individuals who have undergone treatment for breast cancer in the past. Breast ultrasound, often known as Breast US, is a supplementary technique used to analyze and classify breast masses that can be felt, evaluate anomalies, and assist with performing biopsies and wire localizations [3]. MRI techniques have demonstrated the capacity to enhance the accuracy and precision in diagnosing breast cancer; however, accurately determining whether tumors are benign or malignant remains a difficult task. Traditional breast MRI primarily examines the structural characteristics and changes in blood flow, [4] offering insights into the physical properties of tumors, blood vessels, and their permeability [5].

The lymphatic system in the breast comprises the underlying breast tissues, superficial lymphatics, and the periareolar lymphatic plexus. The axillary lymph nodes are categorized into levels, with the upper outer quadrant and axillary tail being the most fre-

quently encountered places [6, 7]. The internal mammary nodes are situated in the intercostal gaps adjacent to the internal mammary vessels. Throughout the typical lifespan, the makeup of breast tissue undergoes alterations, with younger women possessing a greater amount of glandular tissue, while hormone replacement therapy helps to maintain glandular breast tissue.

Breast MRI is employed to screen women who have a lifetime risk of breast cancer that is equal to or greater than 20%, especially those who have a family history or genetic susceptibility [8, 9]. It is especially beneficial for people who have undergone breast augmentation and face challenges with mammography. The diagnosis includes suspicious lesions, blood nipple discharge, uncertain palpable findings, and inconclusive results. MRI-guided biopsy is employed to accurately assess the nature of a lesion and to repair tissue after surgery. The MRI can also assist in identifying the initial site of the breast tumor, detecting invasion of the chest wall, assessing the size of the tumor, and guiding the management of patients receiving neoadjuvant chemotherapy [10].

MRI employs radiofrequency pulses and a powerful magnetic field to visualize the distribution of hydrogen atoms in human tissue. The technology offers both 2D and 3D imaging capabilities, which accurately represent distinct tissue characteristics. Furthermore, it may be tailored to capture images of specific tissues [11, 12]. MRI is capable of detecting paramagnetic compounds, such as gadolinium chelate contrast agents, that have the ability to reduce the T1 relaxation period. This enhances the visibility of breast lesions and allows for differentiation between cancerous and non-cancerous growths [13]. Neovascular development in invasive breast cancers leads to increased enhancement after IV contrast injection, resulting in higher signal intensity and brighter pictures [14].

Since 2002, DWI has proven to be effective in differentiating between malignant and benign breast cancers. Malignant lesions exhibit a mean apparent diffusion coefficient (ADC) value of 1.02±0.17 mm^2/s, whereas benign lesions demonstrate an ADC value of 1.57±0.26 mm^2/s. Malignant ADC values are defined as those that are 1.2 or lower, whilst benign ADC values are defined as those that are 1.5 or higher. Post-processing involves doing a quantitative analysis of ADC values, specifically at the region of interest (ROI), in order to prevent necrosis. The cellularity of breast malignancy and ADC value exhibit an inverse association [15]. However, it is worth noting that certain benign tumors may possess high cellularity, leading to low ADC values. Misdiagnosis can occur when abscess and hemorrhage exhibit low apparent diffusion coefficient (ADC) values. Non-mass lesions such as DCIS and fibrocystic disease may go unnoticed on DWI imaging, where the aim of the study was to obtain a cutoff ADC value between benign and malignant breast lesions.

2. Patients and Methods

This study was a planned cross-sectional review conducted in the MRI unit of the Radiology Division at Al-Imam Al-Hussein Teaching Hospital, Nasiriyah, Iraq, over the period from April 2022 to July 2023.

All women with uncertain or dubious breast lesions (BIRAD III, IV, V) were identified by ultrasound and mammogram and referred to the mentioned Radiology department.

All patients underwent an MRI assessment utilising a 1.5 Tesla MR unit (Achieva, Philipis) with bilateral sixteen-channel breast loops prior to the administration of contrast media.

A radiologist performed a radiological examination of the breasts prior to the histological results becoming available.

The images were subsequently evaluated on the workstation. Each lesion was identified in T1, T2, and T2 fat-saturated images, as well as in the contrast-enhanced image. Each lesion was evaluated according to the American College of Radiology BI-RADS breast imaging, encompassing morphology, size, signal intensity, growth pattern, and location. Time-signal intensity curves were generated from individual MR images by positioning the region of interest at the most enhancing region of the lesion. Lesion type, whether mass or non-mass enhancement, was classified as follows:

With respect to:

- Shape: (Oval, round, irregular)
- Edge: (Circumscribed or not, irregular, spiculated)
- Internal enhancement characteristics (homogeneous, heterogeneous rim enhancement, non-enhancing septa)
- Non-mass enhancement (central, direct, segmental, local)

Kinetic Curve Assessment

A- Persistent, considered as probable benign findings.

B- Plateau, considered as an intermediate finding.

C- Washout, considered as probable malignant finding.

The review utilized SPSS rendition 22 to investigate information on breast lesion patients, contrasting mean ADC among harmless and dangerous injuries. Different possibility tables and tests were performed, with a P-worth of <0.05 showing factual importance.

3. Results

Table 1. Age distribution for malignant and benign lesions among the patients

Age in years	Benign (N = 26)		Malignant (N = 20)		P-value
<30	7	26.9%	0	0.0%	
30-39	9	34.6%	5	25%	
40-49	7	26.9%	9	45%	
50-59	1	3.8%	5	25%	**0.024***
≥ 60	2	7.7%	1	5%	
Mean±SD	36.15±10.99		44.6±7.6		
(range)	(16-60)		(35-62)		

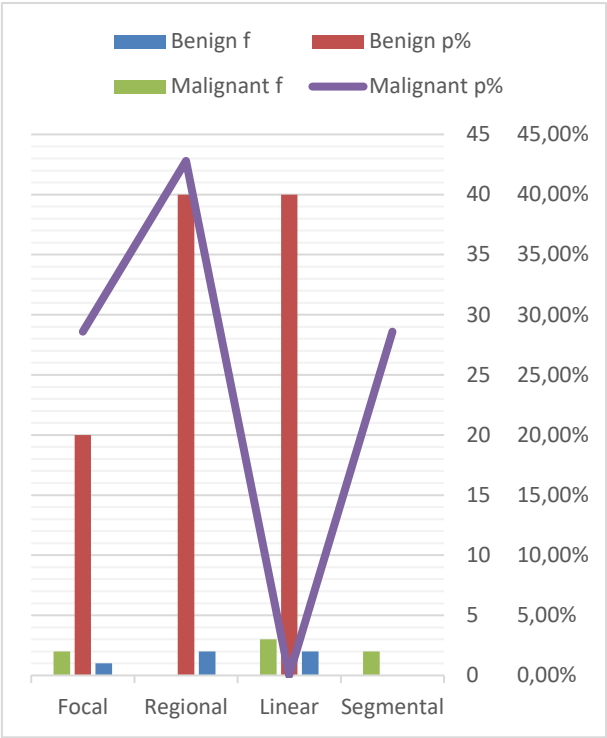

Figure 1. The patients were examined to determine the distribution of NME lesions and obtain histological data

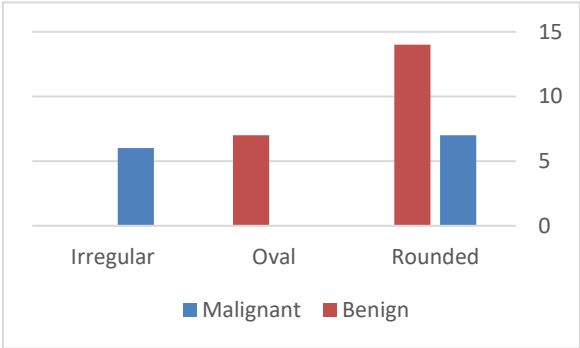

Figure 2. Shape of mass lesion in relation to histopathological reports among patients

Table 2. ADC value (x10^{-3} mm^2/s) result for benign and malignant lesions among the patients

	Benign	**Malignant**	**P-value**
Mean±SD	1.585±0.182	1.149±0.214	<0.0001*
Range	1.330-1.950	0.6-1.480	

*The result was significant at a P-value<0.05.

Table 3. Mean ADC value (x10^{-3} mm^2/s) of ductal carcinoma and non-invasive ductal carcinoma in situ

	No.	%	Mean±SD	P-value
Ductal carcinoma	13	65%	1.089±0.213	0.041*
DCIS	2	10%	1.415±0.091	

Table 4. Mean ADC- value according to the type of lesions among the patients

		No.	%	ADC Mean±SD	P-value
Benign	Mass	21	80.8%	1.538±0.147	0.004*
	NME	5	19.2%	1.785±0.087	
Malignant	Mass	13	65%	1.073±0.201	0.02*
	NME	7	35%	1.29±0.17	

Table 5. ADC Cutoff – value to differentiate between benign and malignant lesions among the patients

Area Under the Curve				
Area	Std. Error	P-value	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
0.948	0.032	<0.0001*	0.940	1.000

ADC Value		
Positive if Greater Than or Equal To	Sensitivity	Specificity
1.121 x10^{-3} mm^2/s	100	100
1.161 x10^{-3} mm^2/s	100	95
1.232 x10^{-3} mm^2/s	100	90
1.325 x10^{-3} mm^2/s	100	85
1.340 x10^{-3} mm^2/s	100	80
1.364 x10^{-3} mm^2/s	100	75
1.382 x10^{-3} mm^2/s	100	70

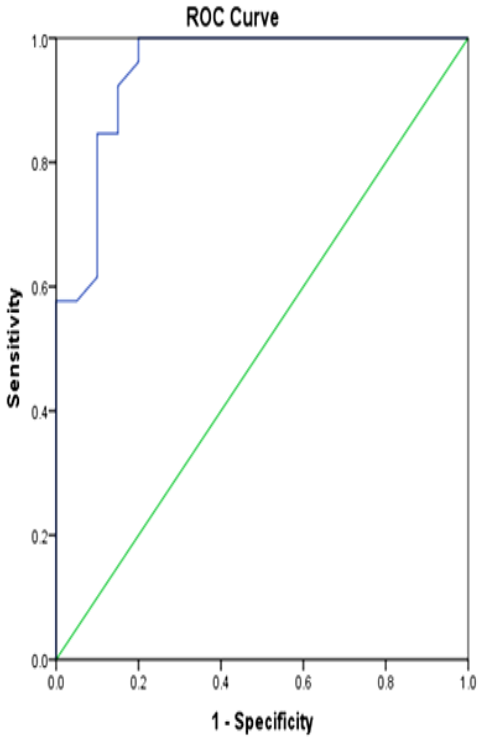

Figure 3. The ADC values at the ROC curve

Table 6. DCE-MRI study, DWI, and combined DCE-MRI study sensitivity, specificity, and accuracy rate

	DCE-MRI	**ADC value**	**BOTH**
Sensitivity	96 %	100 %	100 %
Specificity	85 %	90 %	95 %
AUC	0.906	0.950	0.975
Positive Likelihood Ratio	6.41	10	20
Negative Likelihood Ratio	0.045	0.0	0.0
Positive Predictive Value	89%	92 %	96 %
Negative Predictive Value	94%	100%	100%
Accuracy rate	91.3%	95.7%	97.8%
P-value	<0.0001*	<0.0001*	<0.0001*

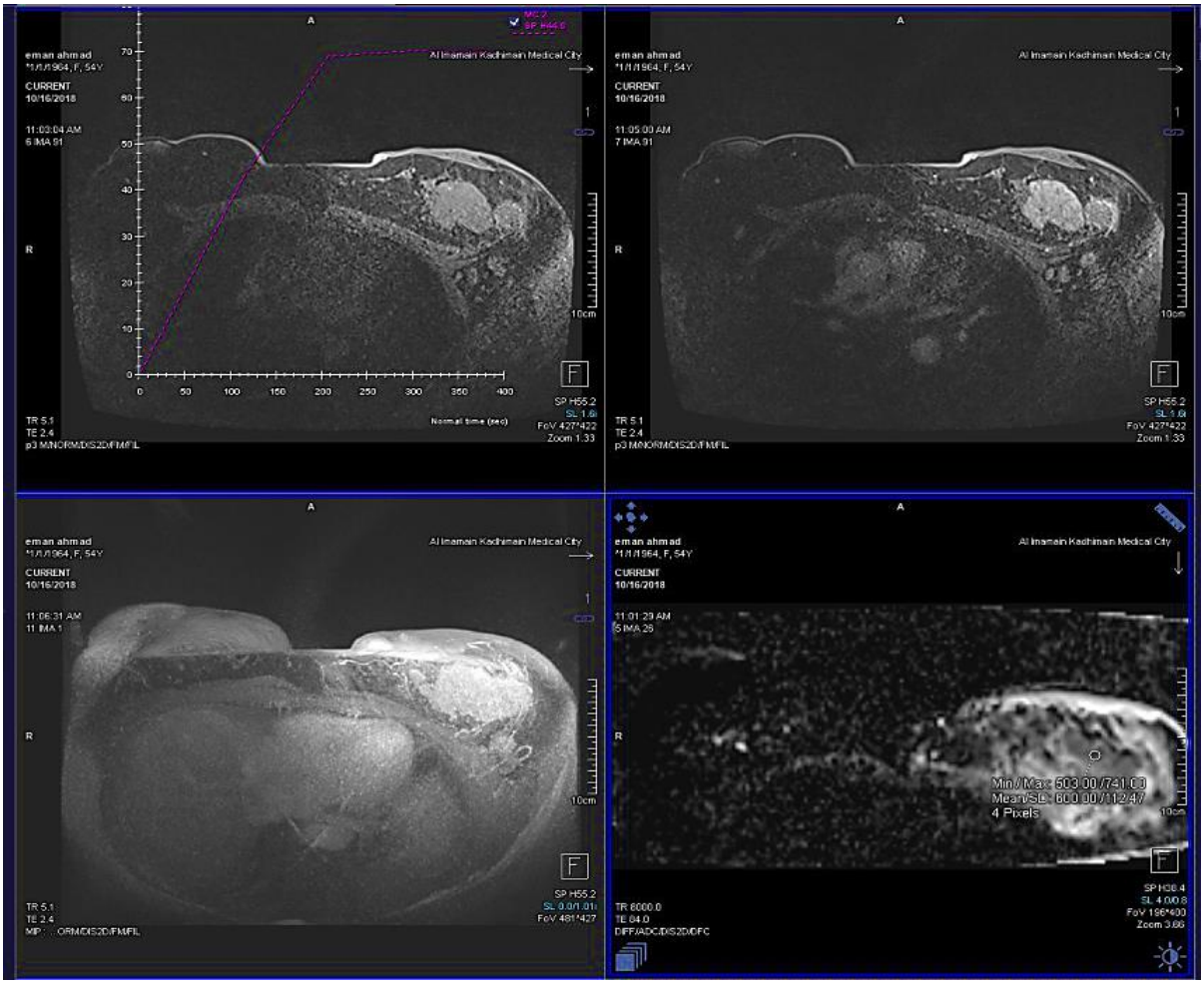

Figure 4. A 54-year-old female breast cancer patient presented with an irregular, ill-defined margin mass lesion and restricted diffusion, resulting in invasive lobular carcinoma

4. Discussion

The review found a cut-off ADC worth of 1.232 x 10^{-3} mm^2/s for recognizing benign and malignant lesions, giving 100 percent sensitivity and 90% specificity. The mean ADC value for malignant lesions was fundamentally higher than for harmless lesions, demonstrating a significant statistical difference. This high sensitivity and specificity are in accordance with past examinations utilizing comparable ADC values [16].

The study found that the mean ADC value of DCIS was higher than IDC, possibly due to the aggressiveness of the lesion and the interspersed cancer cells with healthy breast parenchyma. Tumor cells and chronic inflammatory reaction to proteolysis by means of desmoplastic tissue changes lead to a relative or absolute reduction in extracellular water content and may thus limit extracellular water diffusion [17] leading to decreased ADC. Non-mass-enhancing lesions had higher mean ADC values than mass lesions, and benign lesions with benign mass enhancement had higher mean ADC values than those with benign NME. These distinctions can be ascribed to varieties in assessment conventions, ADC estimation, and field strength [18].

The study found that two NME lesions were misclassified as benign by DWI despite having high ADC value readings. This aligns with previous studies comparing mass and NME types, but it is not significant. [19] The present study used DCE-MRI diagnostic criteria, demonstrating high sensitivity for breast malignancy but moderate specificity. The results showed 96% sensitivity and 85% specificity for contrast-enhanced breast MRI.

When combined with ADC values, only one misclassified lesion was falsely taken as benign, increasing the combined DCE-MRI and ADC breast MRI specificity to 95% with 100% sensitivity [20].

Regarding the age of our patients, was ranging from (16-62) years, with a mean value of 36.15 ± 10.99 years for benign lesions and 44.6 ± 6.7 years for malignant lesions. No malignant lesions were traced under 20 years of age. The size of the mass sore didn't fundamentally connect with ADC value, and ductal carcinoma was the most frequent malignant lesion, representing 65%. The investigation discovered that all lesions with a sort III kinetic curve were malignant, and the type II kinetic curve going among benign and malignant. Two NME lesions had an unreliable kinetic curve, showing the kinetic curve type isn't dependable for NME lesions.

Although the result of the distribution of NME was non-significant, but all patients with segmental enhancement were malignant lesions, and all local in distribution were benign; these coordinate with Tozaki et al. and Imamura et al. studies.

Shape of the malignant mass lesions in this study was variable, with mainly round and irregular in shape in 53.8% and 46.2% respectively, besides. The benign lesions were oval and round in shape in 33.3% and 66.7%, separately. This concurs with Hetta et al. In the ongoing review, the edge of malignant mass lesions was irregular and spiculated in (46.2% and 53.8%) respectively, and all benign masses were had all around the well-circumscribed margin. This is equivalent with Al-Khawari et al., who revealed that most malignant lesions showed ill-defined margins while benign lesions showed well-defined margins. They likewise revealed that the value of morphologic standards, such as the shape and edge of the lesion to depict MRI-detected breast lesions, has been restricted by the absence of a conclusive characterization plot.

Regarding the pattern of enhancement, the malignant lesions show a heterogeneous pattern in 11 (55%), rim in 6 (30%), clumped in 3 (15%), while the benign lesions show a homogenous pattern in 12 (46.2%), heterogeneous in 8 (30.8%), focal 3 (11.5%), and non-enhancing septa in 3 (11.5%), with significant P-value. This is in concurrence with Tozaki et al.

5. Conclusion

DWI is a decent demonstrative tool for breast lesion characterization and is recommended to be on the standard breast MRI examination.

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