



Diagnostic Value of diffusion-weighted MR and MR spectroscopy in the differentiation of benign from malignant breast lesions: An review of Updated literature

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Abstract:

Breast lesions affect women in a variety of ways (both benign and malignant). Breast cancer is the second greatest cause of death in women, invasive ductal carcinoma (IDC) is being the most common pathological type. The most frequent benign breast lesion, especially in young women, is fibroadenoma. Ultrasound and mammography are two common diagnostic imaging techniques that can be utilized for screening and diagnosis of any breast lesion as well as early cancer detection. DCE-MRI is required for morphological evaluation of the mass's nature, extent, enhancing pattern, and staging. DWI and MRS are functional MRI imaging modalities that help correctly characterize and diagnose the type of any breast disease by detecting the degree of restriction at DWI with ADC maps analysis in addition to detection of the level of choline and lipid peaks at MRS. The use of DCE-MR and MRS in conjunction with DWI resulted in a more accurate result in discrimination between malignant and benign lesions, reducing the need for additional unnecessary biopsy and these methods can be used without DCE-MR in cases where contrast injection is contraindicated.

Keywords: (DW-MRI): Diffusion magnetic resonance imaging Breast. (1H-MRS) : Proton magnetic resonance spectroscopy. (ADC): Apparent diffusion coefficient. (DCE-MRI) : Dynamic contrast enhancement MRI. IDC: invasive ductal carcinoma

Introduction

Women are affected by a wide range of benign and malignant breast lesions. Breast cancer is a disease that knows no bounds or boundaries, as it can strike women of all ages ⁽¹⁾. Breast MRI has become an important aspect of breast imaging protocols since it may detect cancer with a high degree of sensitivity and specificity ⁽²⁾. Functional MRI techniques can assess tumor progression by measuring biomarkers of tissue properties ⁽³⁾. The pattern of enhan-

cement and type of enhancement curve, time–signal intensity curve (TIC), dynamic contrast-enhanced MRI (DCE-MRI) of the breast can detect minute vascularity of the tumor, although it is hampered by its low specificity. Diffusion-weighted MRI, quantitative apparent diffusion coefficient (ADC) mapping and proton magnetic resonance spectroscopy (1H-MRS) are some of the other functional MRI parameters that

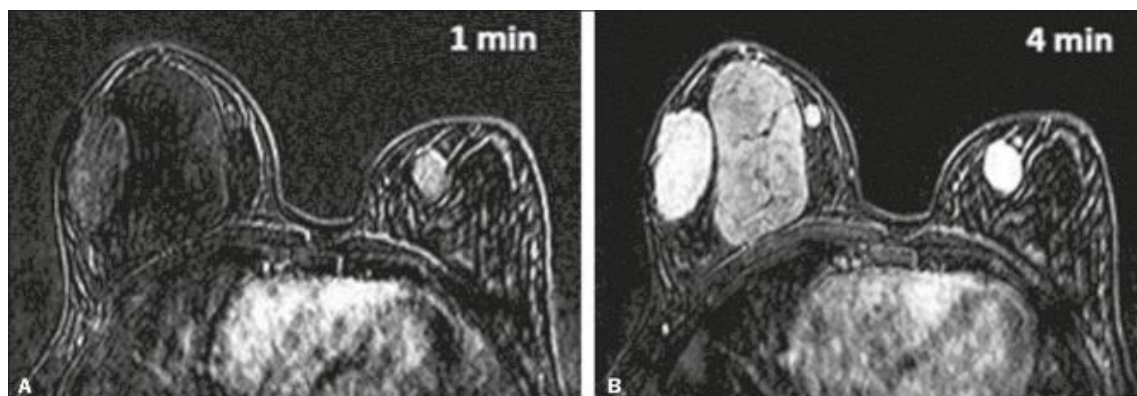
will provide additional specificity and sensitivity ⁽⁴⁾. The exchange of water molecules (diffusion) between compartments of breast tissue is described by DWI, and the rates vary between pathologic and normal tissue. ADC is a measurement of water transport in tissues that are calculated using ADC mapping. Several studies have shown that the ADC values vary between benign and malignant breast masses as tumor cellularity has a significant impact on ADC levels. ⁽⁵⁾. MR Spectroscopy (1H-MRS) is a useful imaging technique that can detect and characterize ambiguous breast lesions by non-invasively detecting the relative concentration of biochemical components within tissues. The major choline metabolites discovered by spectroscopy are free choline, phosphocholine, and glycerophosphocholine, which are referred to as total choline (Cho). Choline peak and concentration levels that are elevated can be used as a reliable biomarker for breast cancer ⁽⁶⁾. By applying the DW sequence and MRS to DCE-MR, the specificity and

sensitivity of MRI may be improved, and the number of needless breast biopsies can be reduced. ⁽⁷⁾.

MRI of The Breast: -

MRI is a non-invasive technique that creates a detailed soft-tissue image of the breast and surrounding structures. Its idea depends on that the magnetic field directs hydrogen atoms in the body to line up in a certain way and the radio waves are sent towards lined-up hydrogen atoms, they bounce back, and a computer detects the signals. Different tissues send back different signals. MRI scans of the breast may be done in combination with conventional methods ⁽⁸⁾.

Functional MRI techniques (DW-MRI) with (ADC) mapping and (1H-MRS) are non-invasive methods that can detect and assess tumor progression by the high degree of sensitivity, specificity, and accuracy depending on digital biomarkers of tissue properties. ⁽⁹⁾



(fig 1) Post-contrast T1WI from the first minute (A) to the fourth minute (B) showing gradual intense homogenous enhancement of bilateral mammary fibroadenomas. ⁽¹⁰⁾.

Minimum standards required for performing breast MRI: -

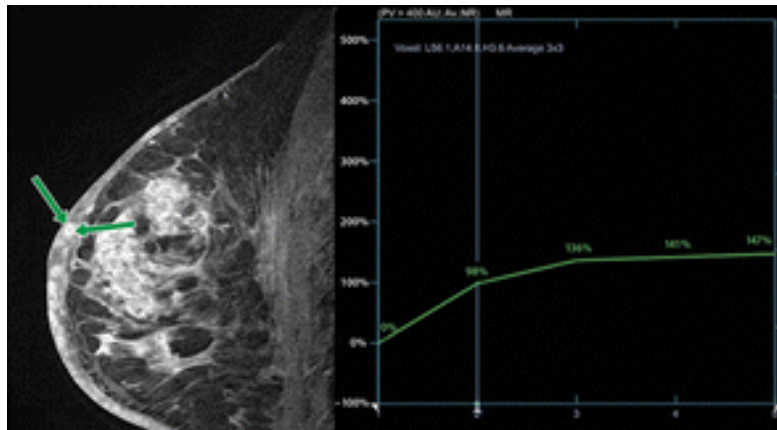
- To perform breast MRI, Minimum magnetic Field strength is at least 1.5-Tesla, using Dedicated breast coils with slice thickness is 3 mm and in DCE-

MR the IV contrast is Gadolinium, its dose is 0.1-0.2 mmol/kg ⁽¹¹⁾.

The principle of DCE-MR is to detect how much the vessels are feeding the lesions by injection of IV contrast gad-

olinium and obtaining T1WI series of images at 15 seconds and after every 2 minutes up to 5-6 phases. After that, a tiny region of interest (ROI) is drawn to detect the curve of enhancement (T-IC), which can be one of three forms, type I (persistent gradual increase in slope) and this type is common with

benign lesions, type II (plateau) curve is detected in 60% of malignant lesions and 40-30% can be detected at benign lesions, the type (III) rapid washout curve, it is common with malignant lesions, its percentage is about(85-90%)⁽¹²⁾.



(fig 2) A 45-year-old lady with inflammatory breast cancer in her right breast, post-contrast T1WI indicates enhancing lesions with thick skin (arrows). The type II plateau curve can be seen in the time-signal intensity curve. ⁽¹³⁾.

MR SPECTROSCOPY (¹H MRS) FOR BREAST LESIONS: -

¹H MRS occurs in a relatively short time and does not require IV contrast; it is part of the standard MRI Breast imaging regimen. MRS Curve has a high degree of sensitivity and specificity in detecting the Choline peak and SNR (signal-noise ratio), which are detectable to a greater extent in malignant lesions than benign lesions, especially when paired with DCE MRI data. ⁽¹⁴⁾.

Technical Considerations: -

Single voxel breast ¹H MR spectroscopy is the most popular method for evaluating a single breast lesion at a time. The voxel is positioned over the ROI, and the spectroscopic curve is created to display the level of choline and lipid concentration in mmol/kg, in order to determine which one is higher or noticeable. ⁽¹⁵⁾.

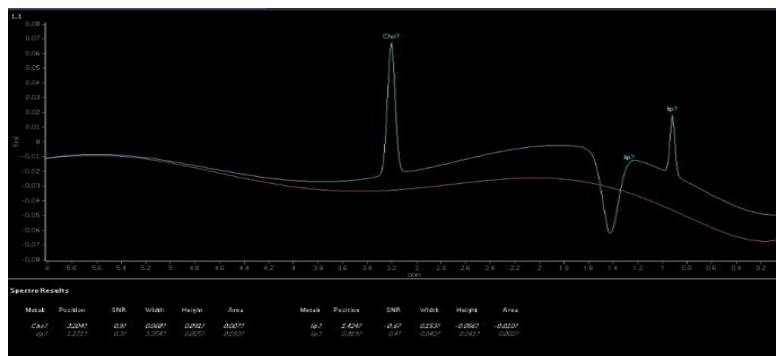


Fig 3) MRS showing high choline level (0.7 mmol/l) at 3.22 ppm in a case of Lt mammary malignant featuring mass which is proved by a biopsy to be IDC (16)

MRS findings would also be considered positive for malignancy if the choline resonance peak's signal-to-noise ratio (SNR) was equal to or greater than 2. (17). Because normal breast tissue lacks choline, the presence of a positive choline peak is a marker of cancer. (16). The elevated choline level in malignant breast masses was observed to be varied, its lower level was 0.7 mmol/kg, and its upper level reached up to 21 mmol/kg (18).

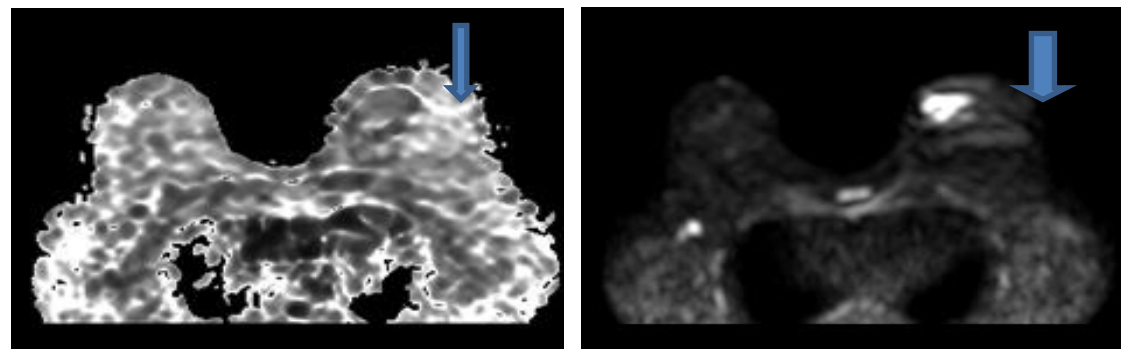
DWI (diffusion-weighted imaging) and the ADC map's role in the diagnosis of breast lesions.

DWI – is a technique for determining tissue qualities based on the distinction between the freedom movement of water molecules (diffusion) in multiple spatial directions, which is determined using the mean diffusivity and apparent diffusion coefficient (ADC) (19).

When compared to benign breast tissues, malignant tumors have restricted diffusion and lower ADC values (20).

Breast DWI Basics: -

DWI of the breasts was obtained in the transverse plane after confirmation of the location of the studied lesions on standard T2WI with fat suppression and before contrast injection, to avoid the effect of contrast material, using a diffusion model of sensitivity encoding (SENSE) single-shot- echo-planar imaging (SSh- EPI) sequence with fat suppression using short tau inversion recovery (STIR) sequence. 500, 1000, and 2000 s/mm2 should be used as variable b- values. Higher b- values produce the greatest outcomes when it comes to detecting quantitative and qualitative ADC maps that were generated automatically based on their ADC values (expressed in 10⁻³ mm²/s) (16)



(fig4) Lt mammary malignant mass with restricted diffusion at DWI at Lt sided image, the low signal at ADC map at Rt sided image and NB...its ADC value was detected as (0.8 x10⁻³ mm²/s) (21)

The ADC Cut Off value is around $0.95 \times 10^{-3} \text{ mm}^2/\text{s}$; the ADC value of the majority of benign lesions is higher than this cut-off value, while the ADC value of the majority of malignant lesions is lower.

The average ADC value for benign breast lesions is $1.4 \times 10^{-3} \text{ mm}^2/\text{s}$ while it is $0.7 \times 10^{-3} \text{ mm}^2/\text{s}$ for malignant breast lesions. Much other earlier research had shown similar results ⁽²¹⁾.

DW-MR and MRS can assess the response of breast malignant lesions to chemo and radiotherapy, and when combined with DCE-MR, they can detect any early changes in the morphology and physiology of the tissue by detecting the level of choline that is reduced after chemo or radiotherapy treatment, as well as the ADC value, being higher and the pattern and curve of enhancement being different. As a result, combining DWI and MRS to DCE-MRI can improve the power of discrimination between malignant and benign breast lesions, improve MRI accuracy, and eliminate unnecessary interventional and biopsy operations. MRS of the breast is also a non-invasive approach that when combined with DWI and ADC mapping by detecting choline presence and ADC value and signal, can provide a higher level of accuracy, sensitivity, and specificity in the distinction of malignant from benign lesions than choline or ADC alone ⁽²²⁾.

Is that a postoperative scar or recurrent breast cancer?

DCE-MR imaging is valuable in the detection and differentiation of recurrent or residual breast cancers from any surgical scar or granulation tissue; as non-enhancing areas are negative for malignancy ⁽²³⁾. The degree of accuracy of MRI breast for detection of recurrent or residual tumor after surgery or adjuvant chemo-radiotherapy is up to 90% ⁽²⁴⁾.

Assessment of postoperative changes as a scar, granulation tissue, and seroma to differentiate them from recurrent malignancy can be done with DWI with ADC value as if there is any neoplastic tissue that is restricted at DWI, low ADC value, and a low signal at ADC map, also spectroscopy can show high choline peak at the site of neoplasm if these results are negative malignancy is mostly not present ⁽²²⁾.

Conclusion

The combined use of DCE-MR with 1H-MRS and DW-MRI & ADC data resulted in greater accuracy in evaluating suspicious breast lesions with good efficient discrimination between malignant and benign lesions, resulting in fewer needless procedures.

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