

Diffusion Imaging of the Breast - Pearls and Pitfalls learned during Routine Clinical Use

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Introduction: The radiologist interpreting breast MRI is often faced with a multitude of enhancing breast lesions and must come to a conclusion as to their potential to represent malignancy vs. proliferative normal glandular tissue vs. fibroadenoma or papilloma. Factors such as lesion morphology and signal intensity (SI) vs. time curve enter into the decision making process. However, in our experience some fibroadenomas and even hormonally stimulated normal glandular tissue may display Type II (plateau) and Type III (washout) SI vs. time profiles, which are, respectively, indeterminate or suggestive of malignancy. It has been nearly two years since we incorporated diffusion weighted imaging (DWI) into our routine clinical protocol. This presentation is image intensive and meant to teach radiologists how to incorporate DWI data into a clinical MRI practice and inform MR scientists of problems which limit widespread application of DWI.

Methods: Echo planar MRI was performed in sagittal plane to conform to the existing breast MRI protocol. Technical factors were: TR: 3000 msec/TE: min (79.3 msec); FOV 24 x 24 cm; Slices: 5 mm skip 1 mm (other clinical sequences: 2 - 3 mm). Matrix: 128 x 128; Nex: 2. B values 0, 1000 mm²/sec. Images were viewed on a commercial workstation with dedicated software.

Teaching Points: 1. Based on an IRB approved study presented 1 year ago, in another forum (blinded for review), we determined that an ADC value of 1.2×10^{-3} sec/mm² represented the best threshold for separating benign and malignant masses.

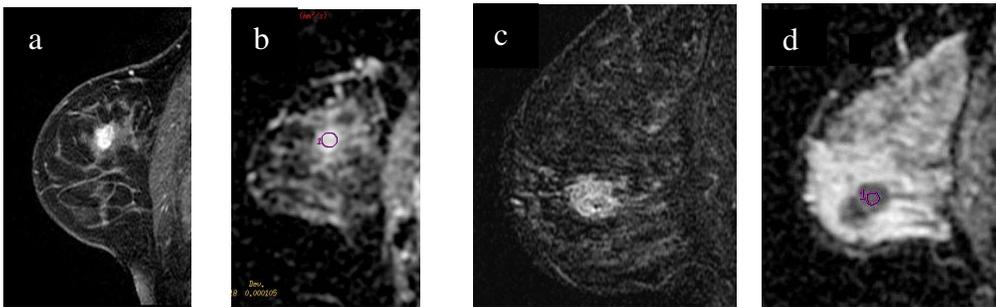
2. DWI imaging is most helpful in confirming fibroadenomas with a higher degree of certainty. We have found that even fibroadenomas that show type III kinetics, consistently display high ADC value.

3. There are severe limitations in utilizing DWI in the clinical environment:

- There is a variable and non-linear image shift between the routine non-EPI based images and the EPI-based DWI images. This can lead to uncertainty as to which ADC value is associated with which lesion. This shift may be the single greatest factor preventing incorporation of DWI into routine breast imaging and will severely inhibit efforts to incorporate DWI into computer aided detection and diagnosis software.
- Fat shows an extremely low ADC value. As a result, partial volume effects may reduce ADC values in non-mass or in small mass lesions into the malignant range.
- Coagulated blood from biopsy or injury, or proteinaceous debris within normal ducts can result in low ADC values and be easily mistaken for malignancy.

Hints for successful use of DWI in the breast:

- Always make sure to correlate DWI results and ADC measurements with *enhancing lesions*. This will avoid falsely positive results from conditions noted in Section 3c, above.
- Use image overlay between ADC maps and subtracted enhanced images to determine image shift. Until technical improvements in diffusion imaging such as implementation of non-echo planar techniques prove robust, the human eye may remain best at determining which ADC value to assign to an enhancing lesion.
- Watch for partial volume effects which might average normal tissue or adjacent fat with small lesions and result in incorrect assignment of ADC value. For small lesions, rather than using ADC value, alternate between b = 0 and b = 1000 images to determine the drop in SI of the lesion relative to surrounding normal tissue.



a: Enhancing fibroadenoma
b: ADC 2.07, higher than surrounding glandular tissue, confirms diagnosis
c: Enhancing invasive breast cancer
d: ADC 0.91 lower than surrounding glandular tissue

Conclusions: After clinically using DWI for 2 years we confirm that, carefully applied, it provides unique information orthogonal to contrast enhancement and can significantly increase confidence in distinction of similarly enhancing benign and malignant lesions. However image shift and distortion associated with currently used EPI will likely inhibit most radiologists from confident use.

Bibliography: 1) Guo Y et. al. JMagn.Reson.Imaging 2002;26:1042. 2) Kinoshita T, et. al. JComput.Assist.Tomogr 2002;26:1042 3) Marini C et. al. Eur.Radiol 2007;17:2646. 4) Woodhams R. J.Comput.Assist.Tomogr 2005;29:644.