Do Advanced MRI Methods Add Value to Routine Contrast-enhanced Breast MRI?

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Introduction: Breast MRI is known to be highly sensitive in the detection of invasive breast cancer due to characteristic morphology and rapid Gd contrast enhancement and washout of these lesions. Specificity continues to be quite variable (1-3), and troublesome especially in the setting of MRI used for staging of known cancer and screening of high risk populations. Over the past decade several sophisticated techniques for improving breast MRI diagnosis have been proposed (e.g. diffusion weighted imaging [DWI], MR Spectroscopy [MRS])(4,5). However, in most scientific studies, a baseline standard and complete breast MRI exam was not used as a basis of comparison to determine if there was any added value to be derived from these sometimes time-consuming techniques. We present preliminary results from an ongoing study that seeks to addresses this issue.

Methods: Patients were recruited from those in whom biopsy results were already known or biopsy was planned. To avoid ambiguities associated with measurement of lesions only patients with suspected or known solid masses were recruited (i.e. clustered microcalcifications were not recruited). A minimum lesion size of 1 cm was required to allow adequate data sampling. Patients with marking clips within a lesion were not accepted unless the lesion was so large that at least 1 cm of tissue remained for measurements. With IRB approval, patients were asked to come on two separate days, at least 24 hours apart (to allow contrast washout), and no more than 7 days apart. All imaging was performed at 1.5 T with an 8 channel receive coil (Signa HDx, GE Healthcare, Milwaukee, WI). On the first day a standard sagittal breast MRI was performed, including T1 and T2 pre-contrast imaging followed by a 3D gradient recalled echo (GRE) sequence acquiring a 3D volume every minute for 8 minutes. The BI-RADS interpretation criteria were used to assess such lesions. On the second day of the study, the standard 3D GRE sequence was replaced by a more rapid enhancement technique (PR-TRICKS or VIPR) to determine the value of sub-minute temporal resolution. DWI, MRS and BOLD (blood oxygen level dependent) imaging were performed on both days to confirm reproducibility. DWI used an EPI technique with b = 0, 1000 s/mm^2. MRS was performed using a commercially available single voxel package (BREASE - GEHC, Milwaukee WI). BOLD imaging used a 16-echo T2*-measurement sequence, with TE's varying from 6.1 and 41.7 msec

Results: Seven patients have thus far been enrolled, 4 with malignant lesions {1: invasive ductal ca (IDC); 1 invasive lobular ca (ILC), 1 mucinous ca (MuC), 1: metastatic melanoma)} and 3 benign lesions {all fibroadenomas (Fb)}. Melanoma and 2/3 breast malignancies displayed Type III kinetics and 1/3 Type I kinetics (MuC). The 3 Fb showed type I, type II and mixed type II and III kinetics respectively. DWI, when not degraded by artifact, typically showed excellent reproducibility (0.2 - 8%). The averaged 2-day ADC values (x 10^{-3} mm^2/sec) for malignancies were: Melanoma 1.02, IDC - 1.03, ILC - 0.697, MuC - 2.4. The averaged 2-day ADC for fibroadenomas were: 2.25, 1.73, 1.66. MRS failed in 1 of 7 patients (melanoma) likely due to marginal size (7 x 10 mm). For the ILC and IDC, unequivocal choline peaks were seen. MRS results for the MuC were ambiguous. 1 Fb showed a moderately strong choline peak and had been noted by the pathologist to have a low probability of being phylloides tumor. Another Fb was thought to have a weak choline peak and the third showed no choline peak. BOLD results were technically adequate in only 4/7 patients and showed that $R2^*$ was 8.8 and 33.2 s^{-1} (Fb) and 22.3 and 21.5 s^{-1} (IDC, ILC). $R2^*$ in adjacent normal tissue ranged from 20.5 - 48.6 s^{-1}. The rapid contrast enhanced series revealed no additional features that were thought helpful in distinguishing benign from malignant lesions and had lower SNR to an extent that essential detail, such as spiculation, might have been missed.

Discussion: In most cases MRS and DWI did not significantly contribute information that might have changed diagnosis over the standard MRI. ILC and IDC were clearly malignant, showing malignant morphology and type III kinetic curves; DWI and MRS simply confirmed the diagnosis. The MuC was the most challenging tumor, showing cyst-like T2 SI, type I kinetic curve and a macrolobulated border. The advanced methods confused the issue, as ADC was 2.4 and no definite choline peak could be identified. All three fibroadenomas showed a benign morphology, but mixed kinetic profiles. One of three Fb showed a Type II curve and an ADC of 1.67 might have been moderately helpful in confirming a benign diagnosis, but MRS showed a weak choline peak and would have misled the radiologist. Similarly, the third Fb showed type II/III kinetics but high ADC (1.71), and moderately strong choline peak. There is some possibility that this was a phylloides tumor instead of a fibroadenoma, but the patient was lost to follow-up. Future technical improvements in sub-minute imaging might include incorporation of parallel imaging and image estimation techniques to improve SNR.

Conclusions: Our preliminary results on seven patients reveal a limited and sometimes conflicting added value from supplementing a complete standard breast MRI with additional advanced imaging methods such as DWI, MRS and BOLD. The more common malignancies (IDC, ILC) were obviously malignant on routine imaging and for the MuC, additional imaging might have resulted in misdiagnosis as benign. Only for fibroadenomas with Type II and III curves might DWI have dissuaded the radiologist that biopsy was necessary. This study is ongoing and we plan to incorporate blinded reading by several breast MRI radiologists to determine how additional information changes their level of diagnostic certainty and biopsy recommendation.

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