Evaluation of the diagnostic accuracy of computer-aided detection of breast cancer using MRI at different temporal resolutions

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Introduction: Several prospective, non-randomized trials have compared the performance of dynamic contrast enhanced magnetic resonance imaging (DCE-MRI), mammography and ultrasound as diagnostic screening methodologies for women at high risk of developing breast cancer [1]. Results have indicated that MRI is the most sensitive modality in this setting. Considerable ongoing research is focused on improving the spatial resolution, temporal resolution and signal to noise ratio of breast MR imaging. This study evaluates the impact of increased temporal resolution on our ability to delineate between the contrast kinetics (temporal information) of malignant and benign lesions with computer-aided detection (CAD) tools.

Methods: Informed consent was obtained from all patients participating in cancer screening and this study was approved by the participating institution's review board. This retrospective study was nested in a prospective, single-institution breast screening study involving 550 high risk women and has resulted in 1749 breast MR exams. Only those exam pairs for which the radiologist ordered a screening and follow-up exam were included in the current study (94 exams for each of 2 imaging protocols). CAD was performed using two different methods, the first being the signal enhancement ratio (SER) method which compares the ratio of the peak enhancement to the final enhancement and was implemented as described in the literature [2]. The second CAD method addressed is support vector machines (SVM) a non-linear method [3]. The gold standard was histopathology (n=94, 24 malignancies, 70 benign lesions) or at least one year of MRI follow-up (mean 2.55 years, range 1-4.92 years) for presumed benign lesions. The MRI prospective screening studies consisted of simultaneous bilateral dynamic imaging using a 1.5T magnet (GE Signa, version 11.4). For the screening protocol, five bilateral volume acquisitions were obtained in 2.8 minute intervals. For the follow-up protocol 11 to 14 unilateral volume acquisitions were obtained in 20-30 second intervals, followed by a 7 minute high spatial resolution fat saturated volume acquisition. Three more unilateral volume acquisitions (20-30 sec.) are performed after the high spatial resolution acquisition to monitor washout. The high spatial resolution volume is used for evaluation of lesion shape information and has not been included in this analysis. A 3D non-rigid breast MRI registration technique was used to compensate for patient motion [4]. Statistical analysis involved comparing the receiver operating characteristic (ROC) curve area of each CAD test for each of the two imaging protocols. We also created visualization scatter plots using principal components (PC) analysis to assist in evaluating differences between the temporal separation obtained for our two imaging protocols (figures 2 & 3).

Results: Figure 1 provides a graph of the area under the ROC curve for both imaging protocols evaluated by both CAD techniques. Figures 2 and 3 provide a visual projection of our temporal data; note that the axis values are not significant, but we are using these plots to visually evaluate the overlap between the temporal information of malignant (red) and benign (green) tissues.

Conclusions: The results reveal little difference between the diagnostic accuracy (as measured by ROC curve area) of the high and low resolution imaging protocols regardless of the CAD method used. This is inline with results in the literature which showed no loss in lesion discrimination at lower temporal resolutions [5]. The low ROC curve areas reported are a result of basing this study only on those patients who have been imaged by both protocols; thus we're examining a population that a radiologist deemed difficult to diagnose. The provided PC space projection plots also demonstrate a high level of overlap between the time curves for malignant and non-malignant lesions for both MR acquisition protocols. These results indicate that diagnostic breast MR protocol researchers should focus their efforts on improving spatial resolution and signal to noise ratio as opposed to further improvements in temporal resolution.

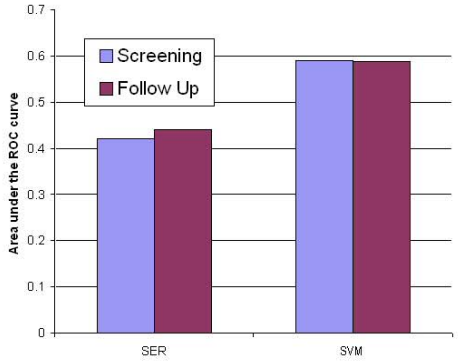

Fig 1. ROC areas for both protocols

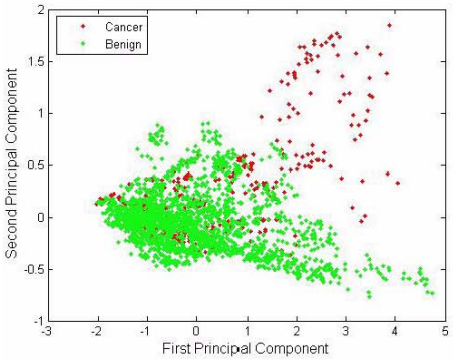

Fig 2. PC space plot of screening data

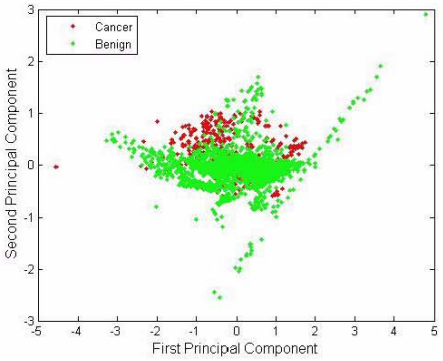

Fig 3. PC space plot of follow-up data

References: [1] Warner *J. Am. Med. Assoc.* (2004) 292(11). [2] Hylton *J. Clin. Onc.* (2006) 24(20). [3] Vapnik The Nature of Statistical Learning Theory, *Springer-Verlag* (1999). [4] Martel *Phys. Med. Biol.* (2007) 52(13). [5] Kuhl *Radiology* (2005) 236(3).