Principal Component Analysis of Breast DCE-MRI: Evaluation of Clinical Protocols at Two Temporal Resolutions

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Purpose: To test and evaluate the ability of principal component analysis (PCA) of clinical breast DCE MRI datasets to perform at two different temporal resolutions and discriminate between benign and malignant lesions, as well as between different malignancies.

Introduction: A wide range of breast dynamic contrast-enhanced (DCE) sequences and protocols, image processing methods, and interpretation criteria were developed and evaluated in the last twenty years. Special attempts were made to better understand the origin of the contrast observed in breast lesions using physiological models that take into account the vascular and tissue-specific features that influence tracer perfusion. In addition, model-free algorithms to decompose enhancement patterns in order to segment and classify different breast tissue types have been developed (1). Recently, PCA adjusted with a model based method was demonstrated to be useful for improving breast cancer diagnosis (2). Here we present extension of PCA to evaluate two clinical MRI protocols that differ in their temporal resolution and analyze their diagnostic ability to detect and diagnose breast lesions.

Methods: DCE-MRI datasets of 52 patients with 77 malignant lesions and 15 patients with 15 benign lesions were analyzed retrospectively. The study was approved by the Internal Review Board of Meir Medical Center (Kfar Sabah, Israel). Two protocols were applied on a 1.5T scanner (Intera, Philips), both applied bilateral, axial 3D gradient echo over the full two breasts with TE/TR = 4.6/10-11 ms at a spatial resolution of 0.66-0.79 mm^2, with time resolution of 80 s (29 patients) or 120 s (38 patients) and a total scanning time of ~ 10 min. GdDTPA (magnetol, Soreq, ISRAEL) was injected as a bolus at a dose of 0.1mmol/kg.
PCA was performed on enhancement scaled datasets of a central slice of each lesion. Based on this analysis a median eigenvector base was constructed. The base was rotated to achieve maximal correlation with model based parameters as previously described (2). Projection of the temporal patterns in each voxel onto the eigenvectors yielded projection coefficients maps presenting the spatial distribution of these coefficients. ROC curves were applied for the assessment of the diagnostic relevance of the various steps.

Results and Discussion: The first two PCA derived eigenvectors (EV) captured signal changes due to tissue contrast-enhancement and were diagnostically relevant, whereas the remaining eigenvectors captured noise changes. Projection coefficients map of the 1st EV detected enhancement of both benign and malignant lesions, whereas projection coefficients of the 2nd EV were useful in differentiation benign from malignant lesions. The results for both protocols confirmed the ability of the 2nd projection coefficient map to discriminate with high sensitivity and specificity between benign and malignant lesions. Moreover, analysis of the higher temporal resolution datasets showed for the 2nd EV a disparity between invasive ductal carcinoma (IDC) and invasive lobular carcinoma (ILC) (Figure 1a,b). Consequently, the projection coefficients of the 2nd EV were higher in IDC as compared to ILC (Figure 1c), distinguishing between these two groups with an area under curve of the ROC curve analysis of 0.84±0.09, using as predictors the percent of voxels within each lesion with projection coefficients greater than 0.

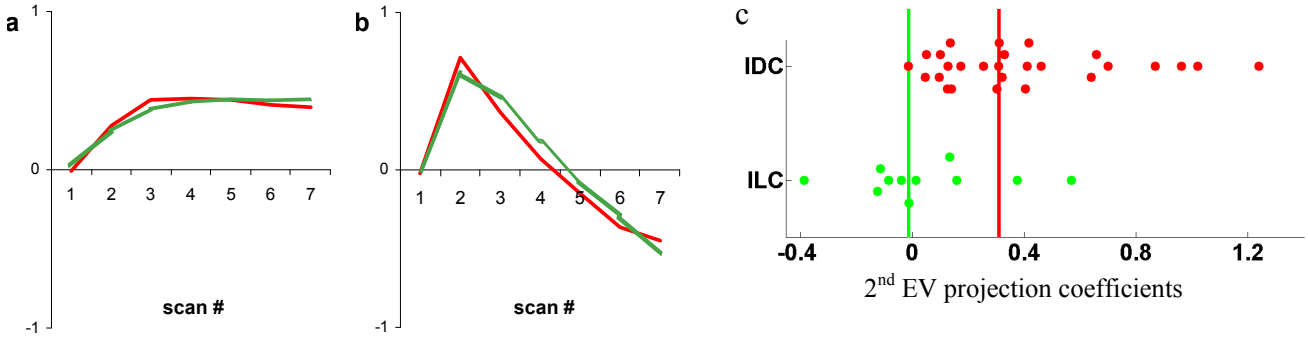

Figure 1. 1st **(a)** and 2nd **(b)** median eigenvectors for IDC (red; n=26) and ILC (green; n=11) and distribution **(c)** of median projection coefficients of the 2nd EV for all IDCs and ILCs (vertical lines indicate median of medians).
The DCE protocol applied a temporal resolution of 80 s with the 1st post contrast at 40 s.

Conclusions: PCA discriminative ability between enhancement patterns, reproducibility (for each protocol) and fast computation of projection coefficient maps (with no need for ROI selection) provide a standardized, objective tool for computer aided diagnosis of breast cancer.

References: 1. Eyal, E and Degani H. NMR Biomed, 22: 40–53, 2009 and references cited therein. **2**. Eyal, E. et al. JMRI, 30(5): 989-98, 2009.
Acknowledgement: Supported by Israel Science Foundation 235/08