DW-PSIF in Breast MRI

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Introduction: In this work we present the results of a pilot study of DW-PSIF in the breast. DW-PSIF is a steady-state sequence that induces diffusion weighting through application of a spoiler gradient each TR. In this work, we investigate the degree of diffusion weighting in DW-PSIF in the breast as well as the effect on diagnostic accuracy of the improved resolution in the PSIF exams in comparison to conventional EPI-DWI acquisitions in the breast.

Materials and Methods: For this prospective study DW-PSIF and EPI-DWI acquisitions were part of a research protocol that also included our clinical DCE acquisition. Eighteen consecutive patients with previously detected breast cancer or suspicious imaging findings were included. Exclusion criteria were patients without follow-up or histopathologic confirmation. Imaging parameters for the DW-PSIF and EPI-DWI were based on the standard imaging parameters used for the EPI-DWI acquisition in our clinical protocol: 34 cm FOV, 256 x 256 matrix, average number of slices 30 (varied to achieve full breast coverage), 2 mm slice thickness/section thickness for the 3D DW-PSIF sequence, EPI-DWI b-values 0 and 600. Diffusion weighting with DW-PSIF is described by cycles of spoiling per voxel instead of b-value. DW-PSIF utilized 9 cycles of spoiling per voxel.

Image analysis consisted of a two-part blinded review carried out independently by 3 dedicated breast radiologists. For the first part, to evaluate the effect of DW-PSIF on diagnostic accuracy, image sets of EPI-DWI only, combined EPI-DWI and DW-PSIF images, and contrast enhanced MR images only were created in random order. Three separate reading sessions were performed with at least a 3-week interval to minimize any learning bias. Each reading session contained one third of EPI-DWI only, combination of EPI-DWI and DW-PSIF, and contrast enhanced MRI images, randomized and presented in alternating order. All readers were requested to assess the lesion morphology including shape (oval, round, irregular), and margin (circumscribed, irregular, spiculated), and final assessment using BI-RADS classification.

For the second part of image analysis, we evaluated image contrast, quality and artifact of bilateral EPI-DWI images, and DW-PSIF images in comparison to these image characteristics in T2 weighted 3D FSE, and pre and post contrast T1 weighted image. All images of each case were presented side by side. Image quality was scored according to six categories: fat suppression (5 point scale), perceived signal to noise ratio (SNR) (5 point scale), sharpness (4 point scale), distortion (5 point scale), aliasing/ghosting artifacts (5 point scale), and clip artifact (5 point scale). Regarding image quality analysis, 1 indicated no or minor things interfering image quality, and 4 or 5 indicated non diagnostic image.

Results: For all 18 patients, histopathologic proof was available for 29 lesions, including all breasts with carcinoma (n = 22). Malignant histology includes 4 DCIS, 17 IDC with or without DCIS, and 1 ILC. There were 9 patients who had presumed benign lesions without pathology, 7 patients with pathology-proven benign lesions (1 usual ductal hyperplasia, 1 atypical lobular hyperplasia, 1 fibroadenoma, and 4 adenosis). On MRI, the mean value of maximal diameter of the lesion was 2.2 ± 1.53 cm (range, 0.5-7.5 cm). The mean ADC value of benign lesions was 1.776 ± 0.499, and that of malignant lesions was 1.195 ± 0.323, and it was statistically different ($P < 0.001$).

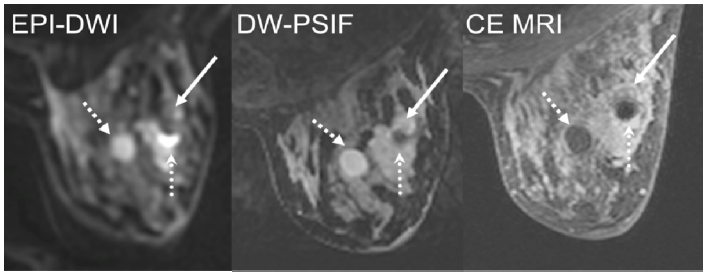

Figure 1. Patient volunteer with cyst (square dotted line), clip artifact (sphere dotted line), and IDC (solid arrow). DW-PSIF demonstrates improved lesion margin delineation and less clip artifact in comparison to the EPI-DWI image.

Using a cut-off point between BI-RADS final assessment category 3 and 4, the sensitivities for DW-PSIF+EPI-DWI, EPI-DWI only, and CE MRI only were 91%, 86%, and 100% for reader 1, 91%, 73%, and 100% for reader 2 and 82%, 64%, and 100% for reader 3. The mean sensitivities of the three readers for DW-PSIF+DWI were significantly higher than EPI-DWI only (88% vs. 74.%, p = 0.023), and significantly lower than CE MRI (100% vs. 88%, p = 0.008). The specificities for DW-PSIF+EPI-DWI, EPI-DWI only, and the CE MRI only were 56%, 44%, and 44% for reader 1, 63%, 75%, and 44% for reader 2 and 63%, 69%, and 56% for reader 3.

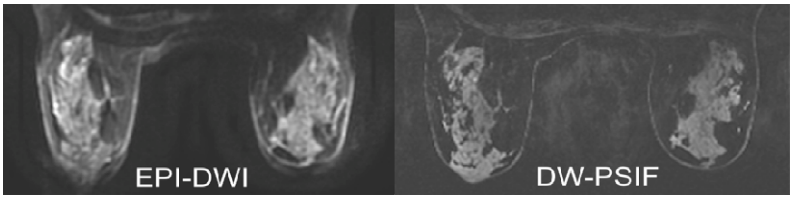

Figure 2. DW-PSIF images demonstrated reduced distortion, improved uniformity of fat suppression and increased sharpness in comparison to their DW-EPI counterparts.

Regarding BI-RADS description for mass shape and margin on MRI, there were significant differences between benign and malignant masses in all three sequences. Among 114 masses depicted by 3 readers on CE MRI, 96 masses were depicted on DWI, while 102 lesions were depicted on DW-PSIF. On DWI, 72% of malignant masses were assessed to have irregular shape and irregular margin. Spiculated margin was noted in only 7% of the malignant masses. However, on DW-PSIF, over 90% of malignant masses showed irregular shape and irregular or spiculated margin.

Overall image sharpness, and uniformity of fat suppression, was rated as significantly higher for DW-PSIF compared to bilateral EPI-DWI (Figure 1). In addition, the overall noise was lower for DW-PSIF compared to bilateral EPI-DWI. Reduced distortion in DW-PSIF was evident (Figure 2). Ghosting artifact was perceived to be equivalent in both sequences (p = 0.505). Regarding image contrast, DW-PSIF showed higher mean contrast for surrounding fibroglandular tissue than T2 CUBE (p = 0.03) and precontrast T1 image ($p < 0.0001$). However, the mean lesion contrast to surrounding tissue in DW-PSIF was lower than that of EPI-DWI (p = 0.0002), and CE-MRI ($p < 0.0001$).

Discussion and Conclusion: In this small pilot study, the addition of DW-PSIF to EPI-DWI improved diagnostic accuracy by enabling more accurate assessment of lesion margins. DW-PSIF also provided higher resolution, and sharper images of breast cancers without the large distortions common in EPI-DWI images. Improved fat-suppression was also achieved because of the compatibility of DW-PSIF with Dixon fat suppression methods. DW-PSIF demonstrated lower contrast between lesion and surrounding tissue in comparison to EPI-DWI, indicating that while future studies are warranted, they should include increasing the diffusion weighting (cycles per voxel) of DW-PSIF.

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