Comparison of steady-state and spin-echo DWI based on morphological assessment of breast lesions

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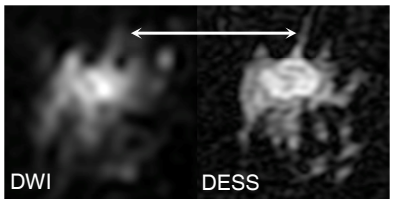
Target Audience: Breast radiologists and engineers interested in steady-state DWI

Introduction

Steady-state diffusion weighted sequences, such as DESS [1,2], use a Cartesian acquisition to acquire images with less distortion and less blurring than with single-shot spin-echo EPI DWI. The DESS sequence has primarily been used for knee imaging, but has the potential to greatly improve diffusion-weighted breast imaging [3,4], where single-shot EPI DWI has limited image quality. To evaluate the potential of using DESS for diffusion-weighted breast imaging, we surveyed radiologists and compared image quality and diagnostic value (relative to pathology) based on assessment of lesion morphology.



Diffusion-weighted breast images
The lower distortion of the DESS sequence enables acquisition of higher-resolution images than with EPI, which improves the depiction of lesion morphology. For the grade 2 invasive ductal carcinoma shown above, the DESS image better depicts fine structures (arrow) and lesion margins.

Methods & Results

The DESS sequence was added to our 3T clinical protocol allowing us to compare DESS to conventional DWI and post-contrast DCE images (gold-standard). Patients were scanned between November 2009 and May 2013 following an IRB-approved protocol. Only lesions with pathology results were included. An experienced radiologist identified lesions on DCE, DESS, and DWI images using all available diagnostic information, including findings from MRI, mammography, ultrasound, manual exams, and pathology. Four other experienced breast radiologists evaluated image sharpness and diagnostic value of the images. The radiologists were shown a single image at a time in random order and blinded to the sequence type.

Study overview

Patients w/ lesions	35
Ages	50±11
Lesions found	61
Lesion size [mm]	17(4-50)

Benign lesion types (25)

2 abscesses	2 hematoma
4 ADH	1 papilloma
3 ALH	1 benign parenchyma
4 cysts	1 PFCC
4 fibroadenoma	3 UDH

Malignant lesion types (36)

4 high-grade DCIS
1 angiosarcoma
28 IDC (10 w/ assoc. DCIS)
2 ILC
1 mucinous w/ assoc. DCIS

Distribution of lesions/patient

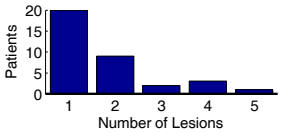


Image quality

The image quality rating includes the effects of image resolution, distortion, blurring, and motion artifact. As expected, both the DCE images were rated as sharper than DESS images (DCE>DESS) and the DESS images were rated as sharper than DWI images (DESS>DWI). The differences in image quality are significant at the p=0.001 level for all but one comparison (Radiologist 1, DESS vs. DWI).

Scan parameters

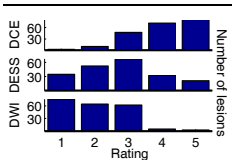
Prescribed resolution		Scan time
Sequence	Resolution [mm^3]	[min:sec]
DCE	0.11 x 0.11 x 1.2	18:08*
DESS	0.09 x 0.13 x 2.5	3:35
DWI	0.21 x 0.21 x 5.0	2:50

* 1 hi-res pre, 14 dynamic (13s), & 4 hi-res post frames

Survey Responses

Rating	Description
1	Very blurry
2	Blurry
3	Average
4	Sharp
5	Very sharp

Distribution of ratings



Wilcoxon Signed-Rank Test

Radiologist	DCE > DESS	DESS > DWI
1	p<0.001	0.05<p<0.10
2	p<0.001	p<0.001
3	p<0.001	p<0.001
4	p<0.001	p<0.001
all	p<<0.001	p<<0.001

Breast Imaging Reporting and Data System (BI-RADS) score

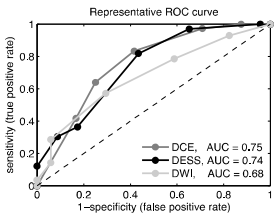
Pathology results were used as the gold standard for determining malignancy. Sensitivity and specificity were calculated using each BI-RADS score as a threshold to generate ROC curves. The area under the curve (AUC) was calculated using trapezoid approximation, and AUC confidence intervals were calculated using multi-reader multi-case analysis software from University of Iowa [5].

The only significant difference in AUC was for the comparison of DCE and DWI (p=0.002). However, there is a trend in the AUC and confidence intervals: the AUC is greatest and the confidence interval is tightest for DCE and the AUC is smallest and the confidence interval is the widest for DWI. The lower endpoint of the DESS confidence interval is greater than 0.5 (corresponding to a random chance test).

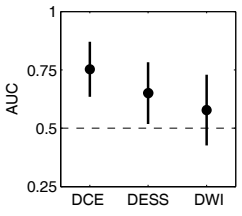
Survey Responses

Score	Description
1	Negative
2	Benign
3	Probably benign
4a	Suspicious
4b	Suspicious
4c	Suspicious
5	Highly suggestive

Representative ROC curves



AUC Confidence Intervals



Discussion & Conclusion

Our patient population included only subjects with lesions, so further study is needed to evaluate the performance in a general screening population. The DESS images were rated as being significantly sharper than DWI images, and the ROC curves of DESS had larger AUCs than those of DWI. Further study is warranted to determine the value of using quantitative information, such as ADC values, and using multiple images, e.g., DESS and DCE together, to improve diagnosis of breast lesions.

In conclusion, we have demonstrated that the DESS images have significantly higher image quality than conventional DWI images for the patients in our study. The higher image quality may facilitate diagnosis by improving the morphologic depiction of breast lesions.

References [1] Staroswiecki MRM 2012, [2] Bieri MRM 2012, [3] Granlund ISMRM 2009, [4] Daniel EJR 2012, [5] perception.radiology.uiowa.edu

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