Repeatability investigation and radiologic assessment of reduced field of view DWI on thyroid glands

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Target audience: Translational researchers investigating imaging biomarkers.

Purpose: Images from conventional full field of view (fFOV) diffusion weighted imaging (DWI) in the region of thyroid glands usually suffer from severe geometric distortion and aliasing artifacts due to its air-tissue interface and human involuntary physiological motions. Reduced field of view (rFOV) DWI technique using two-dimensional spatially selective excitation can excite a small extent in the phase encoding direction without incurring aliasing artifacts. This permits a faster k-space traversal for a given spatial resolution in the direction of phase-encoding, with reduction in echo-train length and total readout time that result in reduced geometric distortion. Previously, FOCUS[1], an rFOV DWI technique employing 2D echo-planar RF excitation in a single shot echo planar imaging (ssEPI) sequence has been assessed in different human organs such as spinal cord,[2,3] and breast,[4] among others. In this study, we evaluated its repeatability and assessed its radiologic quality on the image data acquisition of thyroid glands of human subjects. The purpose of this study was to evaluate whether it is feasible to replace fFOV DWI or has an incremental value in diagnostic and quantitative imaging for thyroid cancers.

Methods: *Human subjects:* 9 healthy human volunteers (age: 23-50 years, M/F: 4/5) were enrolled in this prospective study which was approved by local institutional review board. *MRI data acquisition:* All human subjects underwent MRI studies on a GE 3T discovery 750 scanner with an 8-channel neurovascular phased-array coil. The repeatability studies included 3 longitudinal exams (2 weeks apart) with 2 repetitive sessions in each exam. For each subject, the MRI settings of longitudinal exams were set to be identical. For each exam, DWI scans were performed after scout and T2 IDEAL scans. fFOV DWI scans were performed with single shot echo planar spin echo sequence with following acquisition parameters: FO V = 20-26mm, slices = 4-6, thickness = 4-8mm, TR = 6000 ms, TE= minimum, b values = 500 s/mm^2, matrix=160 x 160, NEX=8, ASSET=2. rFOV DWI scans were performed using FOCUS with same acquisition parameters as fFOV DWI except matrix=160 x 64, phase FOV factor=0.4 and NEX=12. *Repeatability investigation:* Regions of interest (ROI) for ADC calculation were prescribed on the lobes of thyroid glands for each subject with a fixed circle area (diameter = 4mm). ADC was calculated at b=500 s/mm^2 using a monoexponential function with noise correction scheme. The analysis of variance (ANOVA) was used for evaluating repeatability of ADC measurements, which was defined to be : repeatability (r) = between-subject mean square /(within-subject mean square+ between-subject mean square), $0 < r < 1$. High value of r shows the variability of ADC measurement mostly comes from the variability between subjects not from repetitive measurements, representing high data repeatability. The repeatability of ADC measurements across sessions and exams for rFOV and fFOV were calculated consequently**.** *Radiologic assessment:* rFOV and fFOV images were assessed and scored by an experienced radiologist based on the following imaging characteristics: anatomic detail, susceptibility and/or susceptibility-induced artifacts; perceived signal to noise ratio (SNR); and perceived clinical utility. Scoring was performed based a 5-point scale as follows: 1- nondiagnostic, 2 - poor, 3- satisfactory, 4 -good, and 5 - excellent.

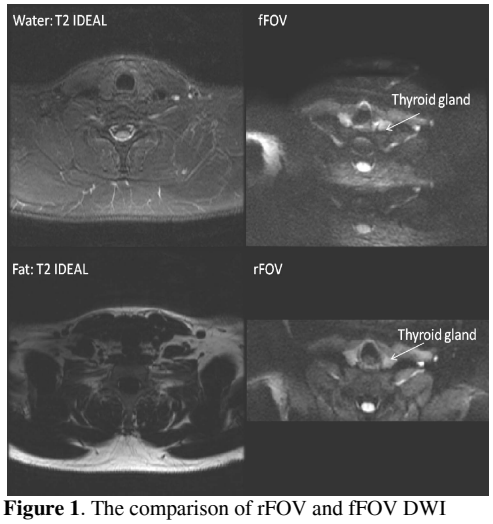

Figure 1. The comparison of rFOV and fFOV DWI images from a representative human subject.

Results: Figure 1 shows the images of T2 IDEAL, fFOV and rFOV DWI from a representative volunteer (28 years old, Male). It clearly shows that the image from rFOV DWI has less distortion and higher clinical utility compared to fFOV DWI. Analyses of all datasets showed that images from rFOV DWI have significantly higher overall image quality (Table 1). For ADC repeatability investigation, ADCs calculated from rFOV DWI were significant lower than that from fFOV DWI. The coefficient of variations of both rFOV and fFOV DWI within and across scan sessions were less than 10%. The repeatability of fFOV DWI was significantly higher than rFOV DWI either across sessions as well as exams (r=0.91 vs. 1 across sessions, and 0.84 vs. 0.95 across exams).

Table 1 The ADC repeatability and radiologic assessment of fFOV and rFOV DWI.

	rFOV	fFOV
ADC Repeatability		
Paired t test (mean±std, $\times 10^{-3}$ mm^2/s, p value)	1.30±0.22	1.71±0.10
	p=0.002*	
Coefficient variation across sessions (mean±std, %, p value)	6.39±3.6	7.62±6.09
	p=0.50	
Coefficient variation across exams (mean±std,%, p value)	9.01±4.94	7.02±6.98
	p=0.57	
Paired t- test across sessions (p value)	p=0.53	p=0.95
Paired t-test across exams (p value)	p=0.79	p=0.82
Repeatability (r) across sessions	0.91	1
Repeatability (r) across exams	0.84	0.95
Radiologic assessment scores (mean±std, p value)		
Anatomic detail	3.21±0.67	2.82±0.88
	p=0.11	
Susceptibility	3.08±0.59	2.60±0.78
	p=0.02*	
SNR	3.13±0.62	2.95±1.02
	p=0.51	
Clinical utility	3.21±0.67	2.78±0.90
	p=0.05*	
Overall quality	3.21±0.67	2.73±0.86
	p=0.04*	

Discussion: This study was the first to evaluate rFOV DWI in thyroid glands. The study demonstrated that rFOV DWI had significantly decreased susceptibility and improved image quality in the region of thyroid glands compared to the conventional technique of fFOV DWI. However, the study also showed that rFOV DWI had less repeatability than fFOV DWI. In similar studies such as in the region of spinal cord, no significance of ADC values was found between these two DWI techniques.[2] However, in a study of pretreatment DWI of breast cancer significant lower values of the 15th percentile tumor ADC (p=0.03) was found in rFOV DWI although no significance (p=0.07) was found between mean values of tumor ADC from these two DWI techniques.[4]

Conclusion: This study suggests that rFOV DWI has potential as an advanced diagnostic imaging method for thyroid cancer, however further study is needed to investigate quantitative differences with this method compared to fFOV DWI.

References

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