Free breathing Liver DWI using PROPELLER-DW-EPI with inherent reductions of geometric distortion and motion artifacts at 1.5T

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Introduction: Quantitative ADC measurement in liver has been shown to facilitate differential diagnosis of simple versus hydatid cyst [1]. Respiratory gated DW-EPI is advantageous over breath holding DW-EPI for liver DWI applications in its increased flexibility for slice coverage if the breath-holding duration is restricted to about 20 seconds, but the repetition time (TR) inconsistency associated with respiratory gated scans may lead to bias in ADC quantification, especially for long T1 tissues such as the hepatic cyst. On the other hand, free breathing DW-EPI is not susceptible to the TR inconsistency-related issues. The aim of this study is to demonstrate a free breathing ADC measurement method using PROPELLER-DW-EPI (periodically rotated overlapping parallel lines with enhanced reconstruction using EPI as signal readout), which has been shown useful for diffusion applications with reduced geometric distortion [2]. The removal of oblique N/2 ghost prior to PROPELLER reconstruction [3] was accomplished using either of two ghost reduction methods: the conventional reference-based [3] and the new reference-free (2D phase-cycled reconstruction) [4] methods, with their results compared.

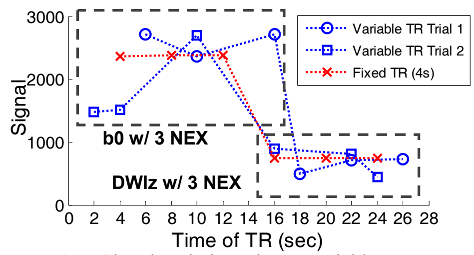

Fig.1 Signal variations due to variable TRs

Table 1

TR	TR intervals (sec)	ADC(x10^{-3})
Var #1	6-4-6-2-4-4	2.33
Var #2	2-2-6-6-6-2	1.62
Fixed	4-4-4-4-4-4	1.94

Materials & Methods: The bias of ADC measurement due to variable TRs during respiratory gated DW-EPI acquisition was evaluated with a water phantom. For simulation of variable respiratory rate, a 3 NEX DW-EPI sequence with sequential acquisition of b0 and DW images was modified to dynamically change TRs during acquisition after dummy scan. The three sets of images were averaged to calculate the ADCs (ADC = ln[DWIz/b0]/-b). The free breathing PROPELLER-DW-EPI data were acquired from a healthy volunteer using an 8-channel phase-array body coil at 1.5T (Signa HDxt, GE) with FOV 36x36cm, blade size 36*128 (ETL=36), rotating angle 15°, NEX 1, TE 78.9ms, TR 4000ms, 8mm slices without gap, 24 blades for 360° k-space coverage, b-values 0 and 500 s/mm^2. Respiratory rate of the subject was around 15-20/min. Scan time was 6:28 for whole liver coverage with 14 slices. The double-FOV reference scans were acquired for all blades (which took an additional 1:40 to acquire) for purpose of reference-based ghost reduction. The reconstruction procedure of multi-channel PROPELLER-DW-EPI data with reference-based and reference-free N/2 ghost reduction is shown in fig.2.

Results: The signal variations due to variable TRs during a 3 NEX DW-EPI acquisition are shown in fig.1, and the calculated ADCs corresponding to two different sets of variable TRs and one set of fixed TRs are shown in table.1. An example of single blade b0 and b500 (figs.2a & d) images from one of the eight channels with reference-based (figs.2b & e) and reference-free (figs.2c & f) methods for N/2 ghost reduction are shown in fig.2. The PROPELLER-EPI b0 images, isotopic DWI images, and the ADC maps reconstructed with reference-free and reference-based methods are shown in fig.3.

Discussion: Our phantom study shows a clearly noticeable bias of ADC measurement for long-T1 substance due to variations in TRs. Although not a severe issue for most hepatic parenchyma and common lesions such as solid mass and hemangioma with T1 less than 1400ms, the bias in ADC measurement may be quite large for the hepatic cyst whose T1 is close to pure water [5]. Consequently, ADC measurement in the liver with free breathing DW-EPI is highly desirable. Results from our study show that free breathing PROPELLER-DW-EPI with reference-free ghost reduction yields image quality comparable to that reconstructed with the reference-based method, with additional advantages of reduction in scan time and elimination of mis-registration between the reference scan and the actual acquisition. In conclusion, our preliminary result demonstrates that free breathing PROPELLER-DW-EPI is a highly procedure for precise ADC measurements in the liver. The inclusion of reference-free ghost reduction post-processing method is particularly suitable in the presence of patient motion and may broaden the clinical use of PROPELLER-DW-EPI in body DWI applications.

References: [1] Inan N, et al, AJR, 189:1031 (2007). [2] Wang FN, et al, MRM, 54:1232 (2005). [3] Chang HC, et al, ISMRM 2011 #4612. [4] Chen NK, et al, MRM, 66:1057 (2011). [5] Tang Y, et al, JMRI, 8:438, (1998).

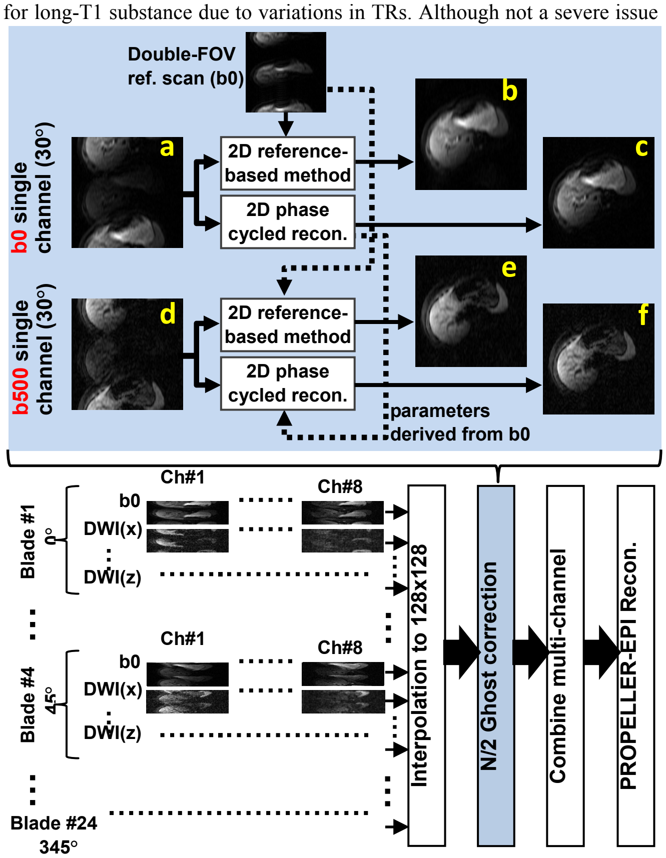

Fig.2 The reconstruction procedure of multi-channel PROPELLER-DW-EPI data with reference-based and reference-free methods.

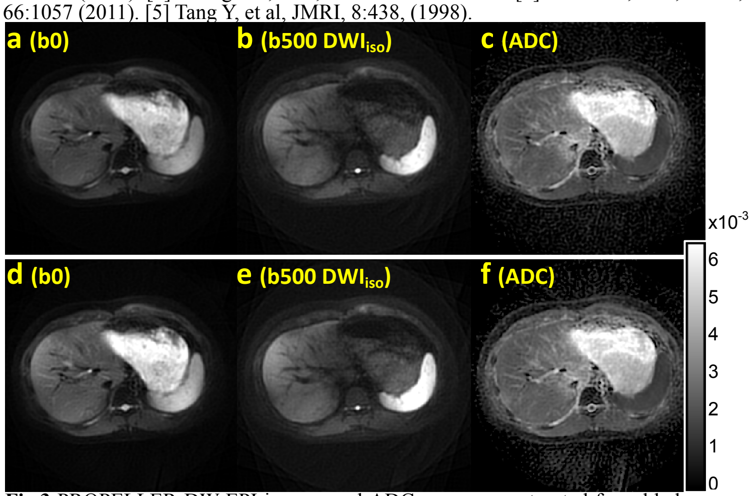

Fig.3 PROPELLER-DW-EPI images and ADC maps reconstructed from blades with reference-free (a-c) and reference-based (d-f) corrections.