High-Resolution Variable Density Spiral Diffusion Weighted Sequence for Prostate and Bladder Wall

Hui Zhang[1], Huijun Chen[1], Wenchuan Wu[1], Xiaoying Wang[2], Feiyu Li[2], Chun Yuan[1,3], and Hua Guo[1]

[1]*Center for Biomedical Imaging Research & Department of Biomedical Engineering, Tsinghua University, Beijing, China,* [2]*Departement of Medical Imaging, Peking University First Hospital, Beijing, China,* [3]*Department of Radiology, University of Washington, Seattle, WA, United States*

Introduction: Diffusion weighted imaging (DWI) has been widely used in clinical setting for detecting cancer-related diseases. Single-shot EPI diffusion weighted imaging (EPI-DWI) is a traditional method as a predictive biomarker for assessment of disease aggressiveness [1]. However, this technique is burdened by severe distortion as well as low resolution and SNR which hamper accurate diagnosis, for example, for cancer detection in the prostate and urinary bladder wall [2]. The interleaved variable density spiral diffusion weighted imaging (VDS-DWI) [3] is a desirable technique with high spatial resolution, reasonable SNR and imaging speed.

Purpose: The purpose of this study is to investigate if VDS-DWI method has the potential application for tumor detection in the prostate and urinary bladder wall.

Methods: A VDS-DWI sequence [4] was implemented on a Philips 3T clinical scanner (Philips, Best, the Netherlands) equipped with a high performance gradient set (60mT/m per gradient axis, slew rate 200mT/m/ms). Pelvic images including the prostate and urinary bladder were acquired from one healthy volunteer and one patient with prostatic hyperplasia (PH) using a 32-channel SENSE Torso/Cardiac coil. These subjects underwent both conventional single-shot EPI-DWI and high resolution VDS-DWI in addition to the traditional standard T2-weighted imaging. Two diffusion imaging sequences were prescribed based on the transverse T2-weighted images to ensure the same structure information among three sequences. They were acquired with different b values: 0, 500, 800 and 800, 1000s/mm^2. For comparison, the EPI-DWI protocols had an in-plane resolution of 2mm and a repetition time of 2000ms and shared the same in-plane FOV of 345×345mm with VDS-DWI and T2-w images. Other imaging parameters includes TE=68ms, SENSE factor=2.5 and half scan factor=0.698. The VDS-DWI protocols had an higher in-plane resolution of 1.5-1.8mm, a repetition time of 1500-2000ms, 16 interleaves, readout duration for each interleave about 10-12.4ms, one diffusion gradient along the phase encoding direction, α=4 (controlling the sampling density[5]), NSA=6. Two resting slabs were applied to suppress vessel signals which might bring artifacts. Total scan time was about 4~6 minutes. Regions including both the urinary bladder and the entire peripheral zone (PZ) and central gland (CG) of prostate were selected. All subjects provided informed written consent.

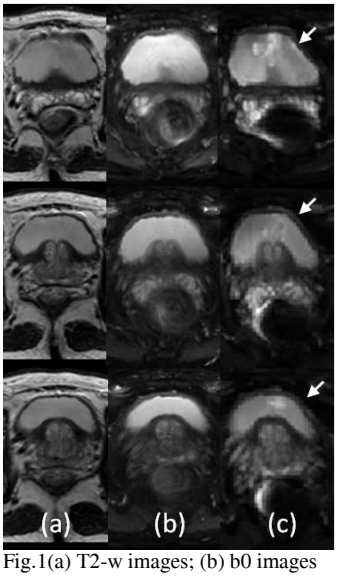

Fig.1(a) T2-w images; (b) b0 images of VDS-DWI; (c) b0 images of EPI-DWI.

Results: Fig.1 shows results from the patient data. We can see that VDS images contain clear boundaries between the entire peripheral zone, junction zone and the central zone, thus provide better contrast and details than EPI-DWI images. Fig.2 shows the data from the health volunteer. The images with various b values (Fig. 2b and c or Fig.2e and f) are shown in the same window level for each method. From the top to the bottom, the pictures present different representative slices. We can see that the images with b=500 (Fig. 2f) and 800 (Fig.2e) of VDS-DWI have sufficient SNR and contrast to noise ratio. They have better details than EPI images (Fig.2b and c) (indicated by the arrows) in the prostate and urinary bladder wall. Additionally, obvious distortions (as indicated by the arrows in Fig. 1c Fig.2b) exist in EPI-DWI. In addition, we calculated the ADC map of VDS-DWI by using mono-exponential model and found that there were very close (<4%) to EPI-DWI.

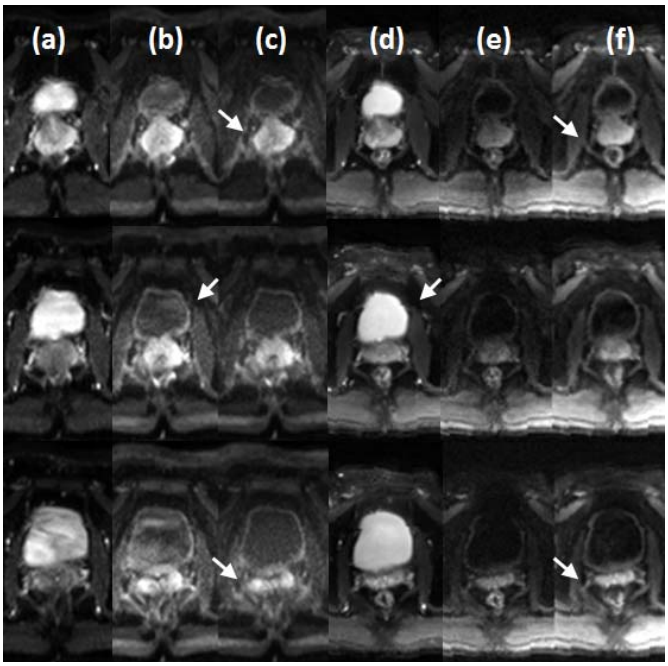

Fig 2. The comparison between two DWI results. (a) b=0; (b) b=800; (c) b=1000; (d) b=0; (e) b=800, (f) b=500. The left three columns are EPI-DWI; the right three columns are VDS-DWI.

Discussion and Conclusions:

In this study, we find that EPI-DWI has severe distortion artifacts for the boundary contours of urinary bladder have deformation for both subjects especially for the fatter subject in the EPI-DWI images, which inevitably interferes with the accurate diagnosis of urinary bladder wall and prostate-related diseases. On the other hand, the VDS-DWI technique can keep the anatomical structure as well as the T2-weighted images (Fig.1). Secondly, less blurring and sharper structure in Fig.2e and Fig.2f indicate that the high-resolution VDS-DWI may have the potential for urinary bladder wall and prostate related disease diagnosis.

This study, for the first time, introduces the VDS-DWI into the prostate application. Comparing with the traditional EPI-DWI based method, VDS-DWI has no distortion, relative higher SNR and higher spatial resolution. Our preliminary results, charactered with well-reserved structural details and high resolution, demonstrate that VDS-DWI has the potential to be used in bladder and prostate disease diagnosis by providing better structural details and high resolution. Further clinical studies are needed to validate this method.

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References:

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