

Respiratory motion artefact reduction on abdominal DWI: Simultaneous use of dual bipolar diffusion gradient and Navigator slice tracking

T. Ogino¹, T. Horie², I. Muro², T. Takahara³, and M. Van Cauteren⁴

¹Philips Electronics Japan, LTD, Minato-ku, Tokyo, Japan, ²Department of Radiology, Tokai University, Isehara, Kanagawa, Japan, ³Department of Radiology, University Medical Center Utrecht, Utrecht, Netherlands, ⁴MR Clinical Science, Philips Healthcare, Minato-ku, Tokyo, Japan

Body DWI has been proposed recently as a sensitive tumour detection method (ref.1). However, in upper abdominal region, respiratory motion affects image quality of DWI. Motion of the diaphragm causes through-slice tissue motion resulting in blurring and misregistration of adjacent slices. Several compensation methods such as breath-holding, respiratory triggering and, more recently, slice tracking with respiratory navigator echo (ref.2) were proposed to minimize these artefacts. Another major issue with abdominal DWI is signal loss in soft tissues. Typically, it is observed in the left lobe of the liver, where cardiac motion is thought to be the main source of the signal loss. However, recent study (ref.3) showed that other areas might be affected too. It was suggested that voxel deformation due to respiratory motion under strong diffusion gradient pulse induces intra-voxel spin phase dispersion that causes signal loss. This effect can be reduced by using a pair of bipolar gradient pulses as shown in a recent study (ref.4). In this work, we evaluated the efficiency of the combined method of dual bipolar diffusion gradient and slice tracking using navigator echoes on 1) reduction of signal loss by respiratory motion and 2) misregistration artefact.

Methods:

Dual bipolar MPG is a pair of bipolar gradient pulses placed around 180° refocusing pulse. This scheme is equivalent to standard 1-2-1 gradient pulse series flow compensation. We refer to it as motion compensated (MC) diffusion gradient.

TRON method (ref.2) is employed as a slice tracking technique. The method acquires navigator echo on a lung-liver boundary to estimate diaphragm shift. The imaging slice location is adjusted in real time with the estimated shift.

Abdominal DWI was performed on 5 healthy volunteers on a 1.5T Philips Achieva system. Scan parameters were: single shot SE-EPI, TR/TE=5000/67 ms, 5 mm thickness, 16 slices, b=0, 500, FOV 350mm, 5 NSA, CHESS fat suppression. Each volunteer was scanned with four DWI methods: 1) conventional, 2) MC, 3) TRON, 4) combined MC and TRON. To reduce variability of respiratory motion throughout the scan, metronome sound was delivered through intercom. Volunteers were instructed to follow clicking sound to keep their respiratory cycle constant.

Results:

Fig.1 shows axial (b=500) DWI images acquired with a) Conventional, b) MC, c) TRON and d) MC TRON. Coronal reformat images from the same scans are shown in Fig.2. Severe signal non-uniformity is noted in the right posterior aspect of the liver on conventional DWI (Fig.1a), but improved with MC (Fig.1b, d). The effect of slice tracking (TRON) is not apparent on axial images but on coronal reformat images. On Fig.2, misregistration artefacts are clearly seen on images without TRON (fig.2-a, b), especially on the boundary between liver and kidney. With TRON, the boundary is visualized sharply and smoothly (fig.2-c, d).

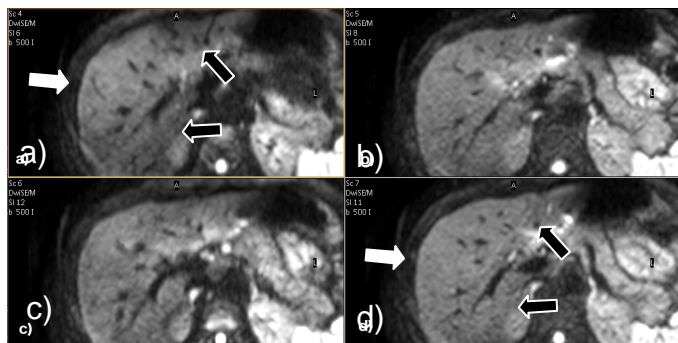
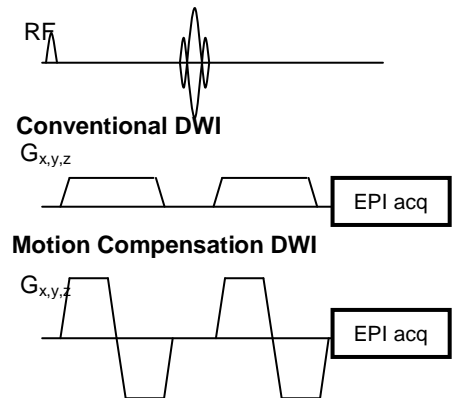


Fig.1 b=500 DWI, a) conv, b) MC, c) TRON d) MC TRON.

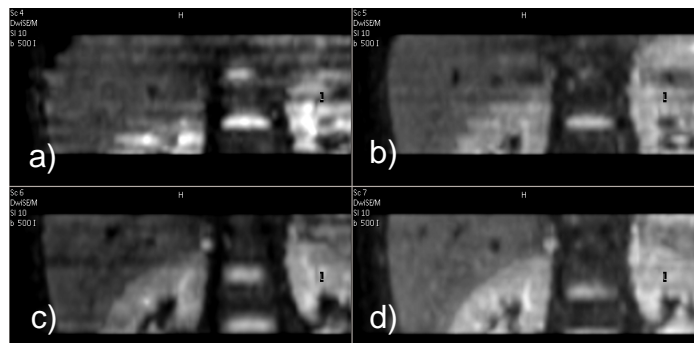


Fig.2 COR reformatting, a) conv, b) MC, c) TRON d) MC TRON

Discussion:

Overall image quality is significantly improved with combined MC TRON method. MC reduces signal non-uniformity of normal liver parenchyma, while slice tracking with TRON suppresses misregistration artefacts on reformatted image. MC TRON is effective for both types of artefact. On abdominal DWI, coronal reformat images are often used for quick screening of tumor presence. Final image (fig.2 d) suggests improved sensitivity for small lesions. Further study on patients need to be performed to confirm this.

Conclusion:

Simultaneous use of MC and TRON produces sharp, smooth and artefact free images on high b-factor DWI. This method effectively improves both major image quality issues of abdominal DWI: 1) signal non-uniformity caused by respiratory motion under strong diffusion gradient and 2) misregistration artefact. We can expect improved sensitivity on body DWI.

References: 1) Takahara T. et al (2004), Radiation Medicine, 22(4):275-282, 2) Takahara, T. et al, ISMRM-ESMRMB 2007. 3) Nasu, K. et. al.(2007) MAGMA, 20:205-221. 4) Gamper, U et al,(2007) Magn Reson Med, 57:331-337