A Novel Whole Body Diffusion Weighted Imaging Technique with Continuously Moving Table: Preliminary Results

Y. Han[1], S. Huff[1], J. Hennig[1], and U. Ludwig[1]
[1]Medical Physics, Dept. of Diagnostic Radiology, University Hospital Freiburg, Freiburg, Germany

INTRODUCTION

Influenced by the successful application of DWI to intracranial diseases, application of multistation DWI to whole-body has been proposed and used clinically for extracranial diseases [1]. However, the clinical impact of wbDWI remains limited due to technical difficulties which are inherent characteristics of multistation approach. As the continuously moving table (CMT) approach has proven to be more homogeneous in terms of temporal and spatial discontinuities between the acquired images [2], improvements in whole-body diffusion-weighted-imaging (wbDWI) methods can be achieved by using the CMT approach. In this study, implementation of a CMT wbDWI sequence and initial experiments were carried out to test the feasibility of a continuously moving table for the wbDWI acquisition.

METHODS

Theory

A CMT technique for wbDWI was developed using a single-shot echoplanar imaging (ssEPI) sequence. Images are acquired continuously for each transaxial slice at the isocenter by moving the patient table at a constant velocity in the *z*-direction. From a simple relationship of $v=s/(N_pTR)$ (1) between the table velocity, v, the slice thickness, s, the number of encoding steps, N_p, and the repetition time, TR, a simplified version can be derived as $v=s/TR$ (2) in case of the ssDWEPI sequence, which acquires each slice data with only one phase encoding step. Once diffusion data are acquired for each slice, images can be reconstructed using a standard image reconstruction method while neglecting the table motion during the acquisition of each slice.

Experimental Setup and Parameters

Experiments were performed on a 1.5T MR scanner (Magnetom Espree, Siemens, Germany) with a bore length of 125cm. Based on the STIR-DWEPI sequence, a single-slice CMT sequence was implemented according to eq.(2). For one female and one male volunteer, wbDWI was performed using the free-breathing CMT-STIR-DWEPI sequence. An informed consent was obtained from both volunteers. The free-breathing STIR-DWEPI was also applied in combination with multistation method as a comparison.

For CMT wbDWI, imaging parameters were as follows: slice thickness=7mm, TE=79ms, TR=2000ms, TI=180ms, NEX=1, matrix size = 128×128, partial Fourier = 6/8, axial FOV = 45×38 cm^2, b = 500 s/mm^2. 150 consecutive ssEPI images (covering a longitudinal view of 1050 mm, from neck to thigh)were acquired at the isocenter of the system using multiple array coils (2 body coils, 4 spine coils, 1 leg coil). The patient table entered the magnet with a speed of 3.5mm/s as determined by eq.(2). The total scan time was 5 minutes. Since all images were acquired at the isocenter and STIR was used as a fat suppression method, no additional shimming was performed for CMT wbDWI.

For multistation wbDWI, the same parameters were used as for the CMT wbDWI except for TR=7800ms. 25 axial slices with slice thickness = 7mm and slice gap = 0mm, i.e. a stationary longitudinal FOV of 175mm, were acquired for each of five consecutive stations, covering a total longitudinal FOV of 875 mm. Because the induced B1 field strength by the human body is not uniform, a shimming procedure at different stations was performed to achieve a satisfying image quality. For each subset, 45 sec. were required for prescan preparations and 14 seconds for the actual scan. Total scan time was 4min. 55 sec.

After successfully performing wbDWI using CMT and multistation methods, high-resolution 3D-maximum intensity projection (MIP) images were reconstructed using a black-white inverse grey scale. For a quantitative comparison, SNR was calculated in the spleen, one kidney and the liver.

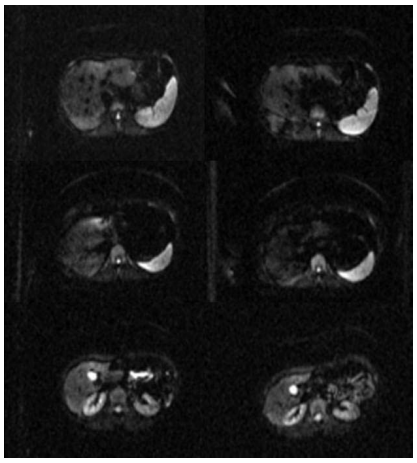

Fig 1. Images acquired with CMT wbDWI (left) and multistation wbDWI (right)

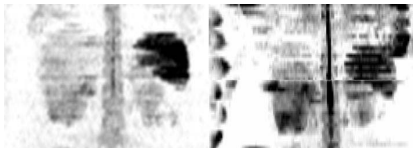

Fig 2. MIP reconstructed from data acquired using CMT wbDWI (left) and multistation wbDWI (right) sequences.

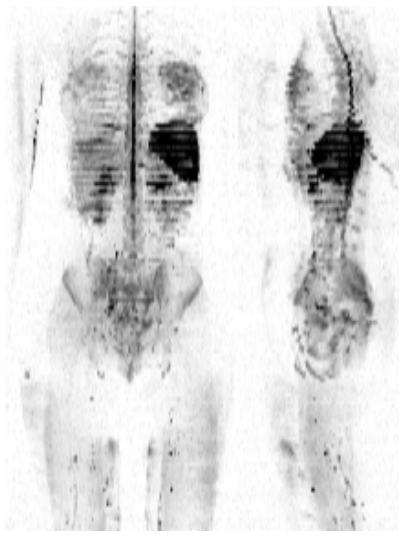

Fig 3. Coronal MIP (left) and sagittal MIP (right) reconstructed from data acquired using CMT wbDWI sequence.

RESULTS

The 2D axial CMT STIR-DWEPI sequence was successfully implemented and whole-body DW images were acquired as shown in fig.1 (left). Images were also acquired using the conventional multistation approach as a comparison to the proposed CMT wbDWI approach as shown in fig.1 (right). When comparing images acquired at similar parts of the body, it is clear that images from multistation tend to have geometric distortions at certain slices while images from the CMT sequence have generally uniform image quality throughout the whole acquisitions.

Using 50 transaxial images acquired from CMT and multistation approaches, MIP images were reconstructed as illustrated in fig.2 to compare the image quality. MIP images of CMT acquisitions show better image quality as fat and normal tissues are successfully suppressed and areas with higher diffusion are shown with lower intensities. The calculated SNRs of spleen/kidney/liver area are 27.6/10.76/18.59 and 27.13/11.23/24.12 for multistation and CMT approaches, respectively, and verifies that the image quality of CMT wbDWI is comparable to currently used multistation wbDWI. It is also remarkable that the background signal in the multistation approach has less homogeneity, and thus results in varying signal intensity. Figure 3 shows final MIP images reconstructed from data acquired with the CMT sequence for coronal and sagittal views.

CONCLUSION

We have demonstrated an easy way to acquire DWI with the CMT approach by implementing a 2D axial CMT approach for DWEPI and the feasibility of CMT approach for the wbDWI acquisition was successfully tested. The reconstructed MIP images showed uniform, continuous views compared to the MIP reconstructed from data acquired with the multistation approach. Especially when CMT wbDWI is used for a MR system with short-bore magnets, images with distinctively superior image quality can be acquired compared to images acquired using the currently available multistation technique. As the images are acquired consecutively at the isocenter of the magnet, various possibilities of spatial and temporal coverage of an extended FOV are offered. For the future, additional techniques such as parallel imaging, image post-processing, and image acquisitions with multiple *b*-values will be implemented, to obtain a great degree of flexibility with regard to the acquisition scheme. This will enable an easier adaptation of wbDWI to various clinical demands for the examination of systemic diseases.

REFERENCES

[1] Takahara T et al. Radiat Med 2004; 22:275-282. [2] Ludwig U et al. Magn Reson Med 2006; 55:423-430.