ADC Quantification of Continuously Moving Table Whole-Body Diffusion-Weighted Imaging

Y. Han[1], S. Huff[2], H. Park[1], and U. Ludwig[2]

[1]Department of Electrical Engineering, Korea Advanced Institute of Science and Technology, Daejeon, Daejeon, Korea, Republic of, [2]Medical Physics, University Hospital Freiburg, Freiburg, Germany

Introduction

Recently, whole-body diffusion-weighted imaging (wbDWI) has been proven to be a beneficial method for patient screening or treatment monitoring because superior disease contrast can be achieved by wbDWI [1,2]. However, the clinical impact of wbDWI still remains limited due to technical difficulties of wbDWI, which is generally performed with a multistation approach. To overcome the difficulties of multistation wbDWI, we have proposed a continuously moving table (CMT) wbDWI method in our previous work [3]. Using CMT wbDWI, images could be acquired with more homogeneity in terms of temporal and spatial discontinuities between acquired images as shown in a reversed gray-scale maximum intensity projection (MIP) of wbDWI in Fig.1. However, more aspects of the CMT-wbDWI have to be validated to utilize this method in a clinical setting. Thus, the influence of continuous table motion on diffusion data was examined in this study by calculating apparent diffusion coefficient (ADC) values using a spherical water phantom.

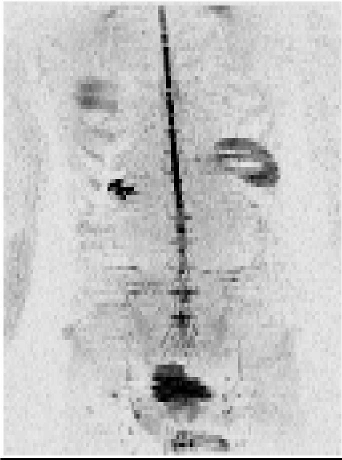

Fig.1. a coronal view of reversed gray-scale MIP generated from DW images acquired with a CMT wbDWI sequence [1].

Methods

By applying the STIR-DWEPI based CMT wbDWI sequence [3] to a spherical water phantom, different sets of images were acquired at a Siemens 1.5T ESPREE using the following parameters: matrix size = 128×128, number of slices = 10, slice thickness=7mm, TE=70ms, TI=180ms, NEX=1, axial FOV = 45×38 cm^2. For b values of 0, 500, 700, and 1000 s/mm^2, CMT-DWI was performed by applying diffusion gradients in different directions of readout (RO), phase-encoding (PE), and slice-selection (SS) directions, for each b-value. These measurements were repetitively performed with TR values of 1500, 2000, and 2500ms, to produce patient table velocities of 4.7, 3.5 and 2.8mm/s. As a result, 36 sets of images (4 b values × 3 diffusion gradient directions × 3 table speeds) were acquired in total. Images were also acquired using stationary DWI as a comparison. For each dataset, ADC values were calculated on a pixel by pixel basis in a region-of interest placed at the center of the spherical water phantom as shown in Fig.2. The ADC values vs. b-values were then plotted.

Results

Fig.2 shows an example of diffusion images acquired with (a) the CMT-wbDWI method and (b) the stationary method. Since the different directions of the applied diffusion gradients had a minor influence (<2%) on the measured ADC values, ADC values of different diffusion directions were averaged to show the tendency according to table speeds. As shown in a plotted graph in Fig. 3, a continuously moving table acquisition method produces increased ADC values compared to a stationary acquisition method. When different table speeds are compared, the table speed of 4.7mm/s produces slightly lower ADC values compared to the table speed of 2.8 and 3.5mm/s.

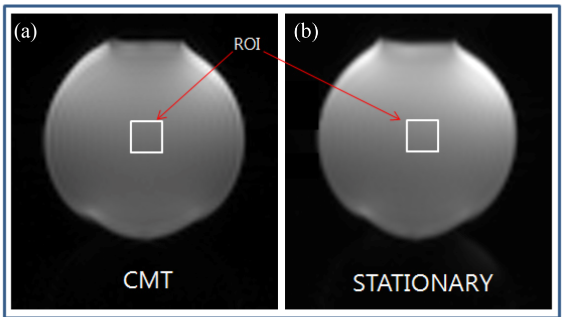

Fig.2. DW Images of a spherical water phantom acquired with (a) CMT method and (b) stationary method. ADC values were calculated from ROIs marked with arrows.

Discussion

As demonstrated by the ADC values shown in Fig. 3, the ADC values of the CMT method are generally higher than those of the stationary method. This is because diffusion phenomenon is additionally influenced by the constant table motion. However, it is also apparent that moving the table at a speed of 4.67mm/s results in slightly lower ADC values compared to lower speeds (2.8 and 3.5mm/s). This effect can be explained by the interference from adjacent slices. If the profile of diffusion gradients is not perfect, some parts of the slices are repetitively affected by the diffusion gradients of adjacent slices, resulting in more diffusion. Since ADC is calculated based on the fraction of signal changes between non-DW and DW images, the amount of signal change is the main source of ADC. Thus, the ADC becomes larger when the signals of the DW images are repetitively influenced by diffusion gradients applied to adjacent slices. If the table moves faster, however, the volume of each 2D slice that is affected by the diffusion gradient of adjacent slices becomes smaller. Thus, a higher table speed can reduce the effect of diffusion gradients applied to adjacent slices, producing reduced ADC values compared to a lower table speed. In short, the ADC values of the CMT DWI are affected by the constant table motion as well as by the interference from adjacent slices. However, the general tendency that ADC values decrease with increasing b-values is preserved in all cases. Although increased ADC values due to table motions are inevitable, the increase due to other sources can be reduced by preventing interference from adjacent slices using techniques such as an interleaved acquisition.

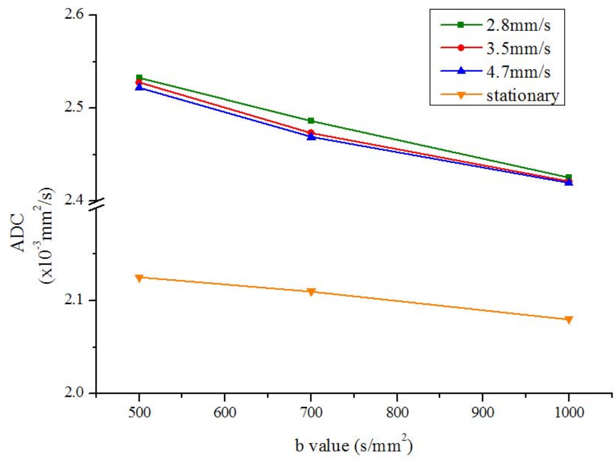

Fig.3. ADC values calculated from images acquired with different b values and different table speeds.

Conclusion

Although ADC values of images acquired with a CMT method are higher than those of stationary images, the general tendency of ADC changes is preserved in all cases.

Reference

[1] Takahara T. et al. Radiat Med 2004; 22:275-282. [2] Li S. Et al. J Mag Reson Imag 2007; 26:1139–1144. [3] Han Y. et al. Proc. 18th Scientific Meeting ISMRM, 2010.

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