

Reduction of signal loss in diffusion-weighted imaging of the upper abdomen: motion correction using bipolar motion probing gradients

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Introduction

In diffusion-weighted imaging (DWI) of the body, incoherent organ motion (e.g., rotation, contraction) often results in significant signal loss. Cardiac motion seems to be incoherent, given the observed signal loss of the heart itself and of the adjacent left lobe of the liver in DWI, and causes poor visibility of lesions and overestimation of apparent diffusion coefficient (ADC) measurements. Our purpose is to evaluate whether DWI with motion correction (MC) using dual bipolar motion probing gradients (MPGs) can reduce signal loss and improve accuracy of ADC measurements in case of incoherent motion.

Methods

Phantoms and volunteer studies were performed at a 1.5-T MR system (Gyrosan Achieva Nova, Philips Healthcare). DWI was performed with and without MC (Fig.1), using b values of 0 and 700 s/mm².

Phantom study: A flowing water phantom with steady flow at an average speed of 10 mm/s and a rotating water phantom with an average rotation speed of 20 degree/s (Fig.2) were prepared. Flow velocity maps of the rotating phantom are shown in Fig.3. ADCs of static, flowing, and rotating water were measured and compared.

Volunteer study: Written informed consent was obtained from all five healthy volunteers. DWI was performed under free breathing and with respiratory triggering. ADCs in the left and right lobes of the liver of all volunteers were measured and compared.

Results

Phantom study: ADCs of static water were 2.2-2.4 x10⁻³mm²/s in all sequences, in both phantoms. In the flowing water phantom, ADCs were 2.2 x10⁻³mm²/s (with MC) and 4.4x10⁻³mm²/s (without MC) (Fig.4). In the rotation phantom, ADCs were 2.2-2.4x10⁻³mm²/s (A-P, F-H, R-L directions) with MC, and 7.8x10⁻³mm²/s (R-L) 7.5x10⁻³mm²/s (F-H) and 4.2x10⁻³mm²/sec (A-P) without MC (Fig.5).

Volunteer study: ADCs of the liver are shown in Table 1. In DWI without MC, mean ADC of the left liver lobe was 65-66% higher than that of the right lobe. In contrast, in DWI with MC, mean ADC of the left liver lobe was only 24-34% higher. In other words, MC is able to reduce the ADC difference between the right and left liver lobe by approximately 50%. Typical results are shown in Fig.6.

Conclusion

Effective motion compensation can be achieved by using our newly proposed MC method with dual bipolar MPGs. This method is quite useful to reduce signal loss and improve accuracy of ADC measurements in case of incoherent organ motion in DWI.

Table 1. Comparison of ADCs of the liver with and without MC

	Free Breathing			Respiratory Triggered		
	R	L	L/R ratio	R	L	L/R ratio
MC (-)	1.46±0.20	2.42±0.23	1.66	1.31±0.09	2.16±0.44	1.65
MC(+)	1.25±0.08	1.55±0.12	1.24	1.23±0.06	1.65±0.13	1.34

L: ADC left liver lobe (mean ± SD), R: ADC right liver lobe (mean ± SD)

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Fig.1. Sequence diagram of MC-DWI

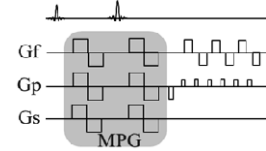


Fig.2. Flowing (L) and rotating (R) water phantoms

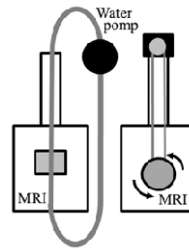


Fig.3. Flow velocity maps of the rotating water phantom in A-P, R-L, and F-H directions

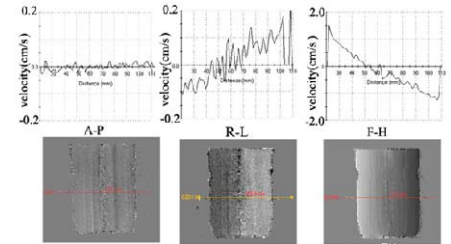


Fig.4. DWI of the flowing water phantom at a flow velocity of 20 mm/s with and without MC

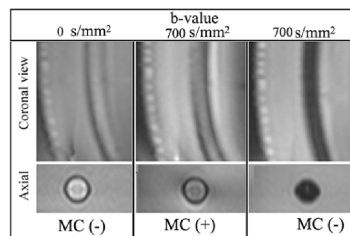


Fig.5. DWI and ADC maps of the rotating water phantom with and without MC

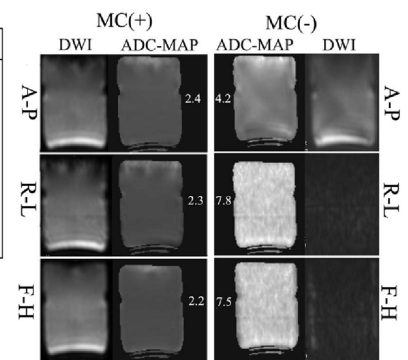


Fig.6. Representative example of differences in signal intensity and ADC between the right and left liver lobe, with and without MC

