

# Improvement of visualization of cardiac wall in diffusion-weighted imaging using cardiac triggering and acceleration motion correction

Tomoya Nakamura<sup>1</sup>, Shuhei Shibukawa<sup>1</sup>, Isao Muro<sup>1</sup>, Nao Kajihara<sup>1</sup>, Hiroaki Nishio<sup>1</sup>, Tetsuo Ogino<sup>2</sup>, Tetsu Niwa<sup>1</sup>, and Yutaka Imai<sup>1</sup>  
<sup>1</sup>Tokai University Hospital, Isehara, Kanagawa, Japan, <sup>2</sup>Philips Healthcare Asia Pacific, Tokyo, Japan

## Introduction

Diffusion-weighted imaging (DWI) of the body has shown the clinical utilities for detection of tumor and for the evaluation of pathologic conditions. However, the cardiac DWI often results in significant signal loss and poor visibility caused by pulsatile motion even though the low b-value and cardiac triggering are used [1]. The purpose of this study was to assess the visualization of cardiac wall in cardiac triggered DWI using motion correction (MC) and acceleration motion correction (aMC) (Fig.1) [2].

## Methods

Motion correction is achieved by the dual bipolar gradients. The first order phase changes can be reduced by MC technique (1-2-1), and the second order phase changes can be reduced by aMC technique (2nd moment nulling). Since dual bipolar gradients result in longer echo time (TE) and reduce the signal noise ratio, we achieved minimizing TE using gradient overplus and dual gradient system. Moreover, slow flowing blood often presents signal in cardiac chamber at aMC-DWI even if the high b-value is used. Therefore, the partial motion correction technique (Fig.2) that slightly stretch the gradient lobe was also used to suppress the blood signal. Cardiac gating was done with either only peripheral pulse unit (PPU) gating, PPU with MC, or PPU with aMC at diastolic phase. Each b-value of 200, 400, 600, and 800 s/mm<sup>2</sup> was set for the cardiac DWI. TE values were set 79ms (shortest TE of aMC-DWI) and best effort values (shortest TE of PPU with aMC: 79ms, PPU with MC: 71ms, and PPU gating: 45ms). Five healthy volunteers (age 22-28) were scanned at a 1.5-T MR system (Achieva Nova dual, Philips Healthcare). Written informed consent was obtained from all volunteers. DWI was performed under free breathing with multiple signal acquisition (number of signal averaged: 3-5). Muscle normalized signal intensity (SI) was calculated and compared among each sequence (Fig. 3). The statistical difference between each sequence was determined by two-way ANOVA.

## Results

Table1 shows the muscle normalized SI at PPU with aMC, PPU with MC, and PPU gating in each b-value. Muscle normalized SI at PPU with aMC (TE79ms) was significantly higher than PPU with MC (TE79ms) and PPU gating (TE79ms) in each b-value. Moreover, muscle normalized SI at PPU with aMC (TE79ms) was significantly higher than PPU with MC (TE71ms) and PPU gating (TE45ms) in each b-value. Visualization of cardiac wall was improved at PPU with aMC compared with PPU with MC and PPU gating even if the b-value of 800 s/mm<sup>2</sup>. A representative case is shown in Fig.4.

b-factor (s/mm <sup>2</sup> )	PPU with aMC TE79ms	PPU with MC TE79ms	PPU gating TE79ms	PPU with MC TE71ms	PPU gating TE45ms
200	1.00	0.56*	0.39**	0.54†	0.27††
400	0.94	0.45*	0.30**	0.47†	0.19††
600	0.94	0.44*	0.29**	0.46†	0.18††
800	1.03	0.45*	0.30**	0.48†	0.17††

Table1 Muscle normalized signal intensity at PPU with aMC, PPU with MC, and PPU gating in each b-value.  
 Note. \*P<0.05 comparing PPU with aMC TE79ms and PPU with MC TE79ms, \*\*P<0.05 comparing PPU with aMC TE 79ms and PPU gating TE79ms, † P<0.05 comparing PPU with aMC TE79ms and PPU with MC TE71ms, and † † P<0.05 comparing PPU with aMC TE79ms and PPU gating TE45ms.

## Discussion and Conclusion

Muscle normalized SI at PPU with aMC is significantly higher than PPU with MC and PPU gating even if the high b-value is used. Cardiac gated DWI with aMC makes it possible to eliminate the pulsatile motion effect and to assess water molecular change in myocardial infarction. In conclusion, we achieved well visualization of the cardiac DWI with aMC.

**References:** [1] Jean-Pierre Laissy,et.al, J. Magn. Reson. Imaging. 2013 Apr 5. doi: 10. 1002/jmri. 24125; [2] Ogino T,et.al, 17th Annual Meeting of ISMRM, Honolulu, 2009 (Abstract2009).

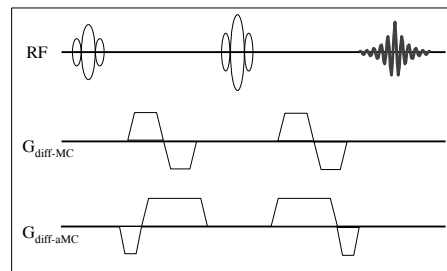


Fig.1 Motion correction and acceleration motion correction.

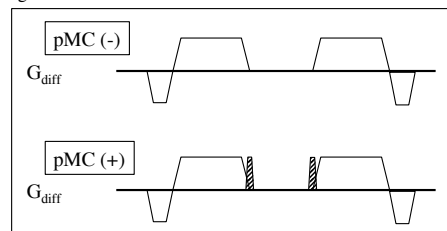


Fig.2 Partial motion correction.

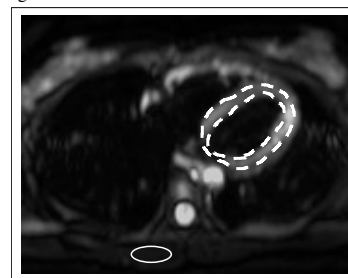


Fig.3 Region of interest at cardiac wall and erector spinae muscle.

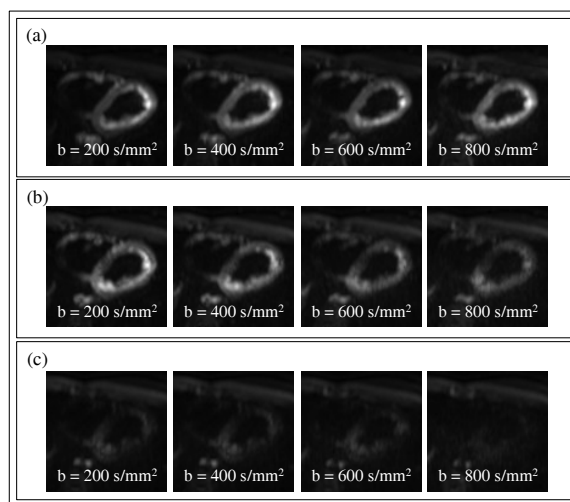


Fig.4 An example of PPU with aMC-DWI (a), PPU with MC-DWI (b), and PPU gating (c).