Motion Artifacts in Diffusion-Weighted MR Images of the Brain: Efficacy of Navigator Echo Correction

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Introduction: Diffusion-weighted magnetic resonance imaging (DWI) *in vivo* provides many applications both in clinical diagnostics (e. g. early detection of cerebral ischemia) and in investigation of cell physiology. However, a limitation to its application in clinical routine is the severe image degradation caused by patient motion and pulsatile brain motion. Typical motion artifacts in DWI are shown in the upper left image in figure 2.

The objective of this study was to evaluate the efficacy of a navigator echo correction (NAV) and pulse-triggering (PT) in DWI in order to reduce image artifacts.

Methods: A Spin Echo sequence and a Fast Spin Echo sequence (echo train length 3) were implemented on a 1.5 T MR scanner with standard hardware ($B_0 = 1.5\,\mathrm{T}$, max. gradient strength $15\,\mathrm{mT\,m^{-1}}$, min. rise time $750\,\mu\mathrm{s}$). The sequences were diffusion-weighting ($\Delta = 45\,\mathrm{ms}$, $\delta = 37\,\mathrm{ms}$, $b_{\max} = 550\,\mathrm{s\,mm^{-2}}$) and extended with an additional navigator echo readout. The navigator echo allows in a post-processing step the calculation of bulk translation and rotation of the examined object during the acquisition [1, 2]. Thereby, motion artifacts can be removed from the images. To reduce image artifacts caused by pulsatile brain motion a finger pulse sensor was used for pulse-triggering.

Motion during the acquisition mainly results in ghosting, i. e. signal outside the imaged object. As a measure of these motion artifacts the *artifacticity* A was calculated describing the ratio of intensity within and outside the imaged object.

The study included 5 healthy volunteers; 4 axial images at different levels above the orbito-meatal line were acquired from each volunteer.

Results: Motion correction with the navigator echo approach and with pulse triggering significantly improved the image quality by reducing motion artifacts.

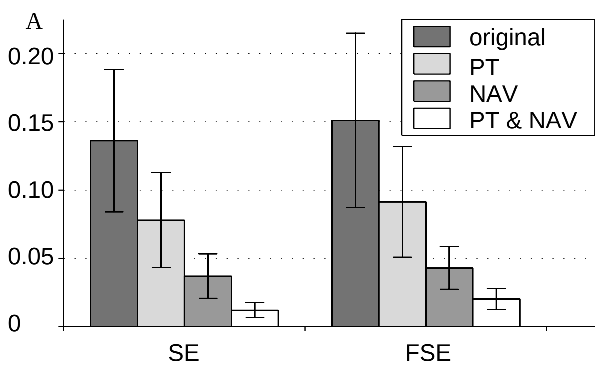

Figure 1: Artifacticity A of images in different stages of motion correction (NAV = navigator echo, PT = pulse-triggering), $b = 550\,\mathrm{s\,mm^{-2}}$.

As shown in figures 1 and 2, using navigator echoes reduced motion artifacts to a higher degree than pulse-triggering. Best results (reduction of artifacticity by about 90 %) were achieved when both correction techniques were combined. These results show that generally most motion artifacts arise from bulk motion of the examined object.

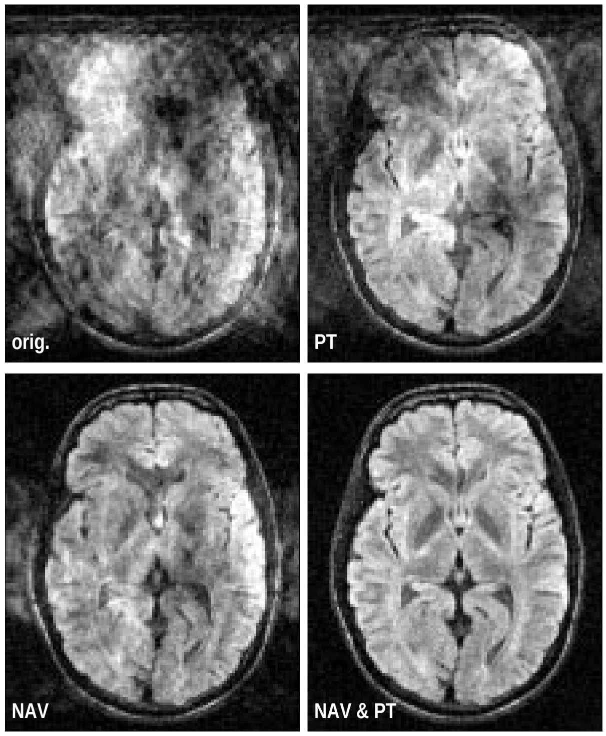

Figure 2: Advancing stages of motion correction (NAV = navigator echo, PT = pulse-triggering), $b = 550\,\mathrm{s\,mm^{-2}}$.

The quality of the navigator echo correction depends on the slice position. Very good results even without pulse-triggering were achieved in slices placed above the ventricles where pulsatile brain motion is directed mainly perpendicular to the diffusion-weighting gradients.

Discussion: Navigator echo correction is a robust method to reduce motion artifacts to a great extent without increase of acquisition time. In combination with multi-echo sequences, high-quality diffusion-weighted images can be acquired even on standard hardware in reasonably short time. Additional pulse-triggering is recommended particularly if the slice contains parts of the ventricles or other tissue affected by pulsatile brain motion.

REFERENCES:

1. Ehman, RL, and Felmlee, JP, Radiology, 173:255-263, 1989.
2. Ordidge, RJ, Helpern, JA, Quing, ZX, Knight, RA, and Nagesh, V, Magn. Reson. Imaging, 12:455-460, 1994.