## Assessment of motion sensitized driven equilibrium (MSDE) improvement for whole brain application

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**INTRODUCTION:** Contrast-Enhancement (CE) magnetic resonance imaging (MRI) is a promising modality for screening of brain metastasis (1). Paramagnetic contrast media exhibits metastatic lesions as hyper-intensities on T1W images. Because blood vessels are also enhanced, it is important to suppress the blood signal in order to reduce potential misdiagnoses (2). Although this can be achieved by a 3D turbo spin echo sequence with variable flip angle, this method still requires validation for whole brain applications. An alternative blood suppression technique, based on motion sensitized driven equilibrium (MSDE) preparation, has been proposed recently (3, 4). Because blood suppression with MSDE is independent of the inflow effects or T1 values of the blood, the technique can be used with 3D acquisition in conjunction with injection of paramagnetic contrast agents. This combination makes MSDE technique better suited for whole brain metastasis screening compared to the more conventional dual inversion recovery black blood technique. However, MSDE preparation is sensitive to both B0 and B1 magnetic field inhomogeneities as well as eddy current (EC) effects. To address these issues at 3.0T, several preparation schemes have been proposed (5-7). MSDE has been mainly used for carotid artery vessel wall imaging, and because of wider anatomical coverage needed for whole brain imaging, field inhomogeneity and eddy current effects should be reconsidered. The purpose of this study was to compare the conventional versus improved MSDE preparation schemes for whole brain application at 3.0T.

**METHODS:** Five healthy adult subjects (mean age 27) were scanned on a 3.0T clinical scanner (Philips Achieva R2) after obtaining informed consent. Fifteen slices were obtained using MSDE prepared 3D gradient echo sequence from a sagittally oriented slab centered on the interhemispheric fissure. Figure 1a shows the conventional MSDE preparation consisting of a 90°excitation pulse, a 180° refocusing pulse and a -90° flip back pulse with motion sensitizing gradients sandwiched in between the RF pulses. In the improved preparation shown in Fig. 1b, the refocusing pulse was replaced by two 180° MLEV refocusing pulses for inhomogeneity control (5,7) and additional bipolar gradients were inserted in front for eddy currents compensation (6). All refocusing pulses were implemented as composite pulses ($90_x$-$180_y$-$90_x$). Durations of the MSDE preparations were set to shortest values, 12.0ms in the conventional and 14.5ms in the improved schemes. Motion sensitized gradients were employed in all three directions and each velocity encoding was set to 3.8cm/s.

Data acquisition was achieved using segmented gradient echo (Turbo Field Echo, TFE) with centric k-space ordering and the following parameters: TR/TE=4.5/2.2ms, Flip Angle=10°, Shot Interval=850ms, FOV=24×24cm, matrix=128×128, slice thickness=5mm, Turbo Factor (TF)=30, NSA=1.

For comparison between the two MSDE preparation schemes, additional reference images with identical imaging parameters but without MSDE preparation were acquired. To achieve blood signal suppression on the reference images, inversion recovery pulse with TI=650ms was used both for reference and MSDE acquisitions. Assessment method: Signal ratio (SR) between MSDE prepared and reference image were calculated. Such normalization removes signal variations due to the receiver coil inhomogeneity, B1 variation of the excitation pulse, imperfect slice profile, proton density differences and tissue T1 relaxation differences. Comparison of conventional and improved MSDE was done at 4 sagittal positions, 10mm and 30mm on the left and right sides from the center line of the brain. White matter masks were generated by intensity thresholding on the reference image to exclude gray matter, CSF and residual blood signal in the vessels. After manual removal of non-brain structures, average SR values and standard deviation (SD) were calculated within the regions in these masks. These values, computed at 4 sagittal positions (labeled p1 through p4 from left to right) were used for statistical comparison (paired t-test) of conventional and improved MSDE preparation schemes.

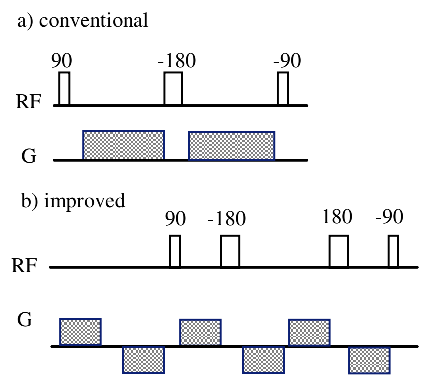


**Fig. 1: Two MSDE preparation schemes**

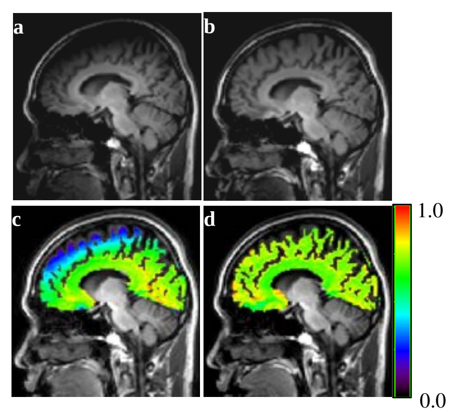


**Fig. 2 MSDE images (a,b) and SR maps (c,d) obtained with conventional (a,c) and improved (b,d) schemes**

**RESULTS**: Figure 2 shows MSDE images and SR maps of one volunteer at slice position p2. Typical signal drop at upper area in the cerebrum can be observed in the conventional MSDE image, but not on improved MSDE image (a, b). Signal ratio maps (c, d) show the same pattern of the intensity uniformity even more clearly. Improvement of image uniformity with improved MSDE preparation was observed in all subjects. Figures 3 and 4 show average values of SR and SD across all five volunteers at four sagittal positions. The SR of improved MSDE was significantly higher ($P<0.05$) than conventional MSDE at all slice positions. The SD of improved MSDE was significantly lower ($P<0.05$) than conventional MSDE at all slice positions.

**CONCLUSION:** Our results show that improved MSDE method produces more uniform images compared to conventional MSDE preparation, indicating that it is less sensitive to B0 and B1 inhomogeneity and EC effects. Therefore it is appropriate for whole brain studies such as metastasis screening. Further clinical assessment is needed to evaluate the efficiency of blood suppression after injection of contrast media and ultimately, the ability to detect and differentiate the lesions.

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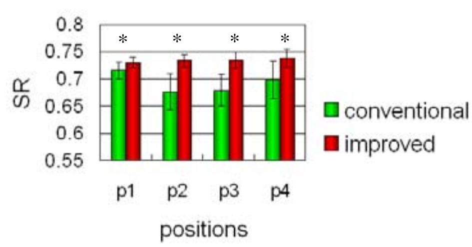


**Fig. 3 SR comparison (*: statistically significant)**

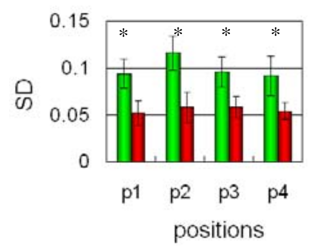


**Fig. 4 SD comparison**