Optimization of motion sensitized driven equilibrium (MSDE) preparation scheme for multi contrast 3D vessel wall imaging at 3.0T

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INTRODUCTION: Motion sensitized driven equilibrium (MSDE also known as Diffusion Prepared) sequence was proposed recently for fast vessel wall imaging (1,2,3). This method is faster and allows wider anatomical coverage than conventional 2D double inversion recovery (DIR) turbo spin echo (TSE) approach. Thus MSDE sequence is a very promising method for vessel wall screening. However, it is important to get appropriate T1 and T2 contrasts for optimal detection of different kinds of plaque composition. The purpose of this study was to optimize MSDE preparation design for 3D T1W and T2W vessel wall imaging.

METHODS: MSDE sequence was implemented on a 3.0T scanner (Philips Achieva R2). In addition to the original MSDE preparation, two MLEV based preparation schemes (4) where also implemented to have a better control of B0 and B1 inhomogeneity effects at longer preparation times. Five healthy adult subjects (mean age 27) were examined after obtaining an informed consent. All images were acquired with the imaging volume centered on the carotid bifurcation without physiological triggering.

MSDE Optimization: Figure 1 shows the three MSDE sequences that were compared: (a) RFP1: conventional MSDE preparation consisting of 90° excitation pulse, 180° refocusing pulse sandwiched by motion sensitizing gradients and -90° flip back pulse, (b) RFP2: two 180° MLEV refocusing pulses with each pulse sandwiched by bipolar motion sensitizing gradients, and (c) RFP4 : four 180° MLEV refocusing pulses with corresponding bipolar motion sensitizing gradients. All refocusing pulses were implemented as composite pulses (90x-180y-90x). For the RFP2 and RFP4, additional bipolar gradient was inserted in front of the sequence for eddy currents compensation (5). Because MSDE preparation time (Prep TE) should be short enough for T1W to prevent T2 decay effects, only RFP1 and RFP2 were compared for T1W optimization. Prep TE was set to the shortest values, 12.1ms in RFP1 and 15.2ms in RFP2, for T1W. For T2W acquisition, Prep TE of RFP1, RFP2, and RFP4 was set to 40ms. Velocity Encoding was set to 3.8cm/s for T1W and 2.4cm/s for T2W. Segmented gradient echo (Turbo Field Echo: TFE) followed the MSDE preparation for the data acquisition. Acquisition parameters for T1W were: TR/TE=5.1/2.6ms, Flip Angle=20°, Shot Interval=800ms, and for T2W were TR/TE=6.0/3.0ms, Flip Angle=15°, Shot Interval = 1800ms. Other common sequence parameters were: FOV =12*12cm, matrix = 176*176, slice thickness/gap =3/0mm, number of slices = 15, Turbo Factor (TF) = 30, SENSE Factor (SF) = 2, NSA = 2, Over sampling factor (OS) = 2. Scan time for T1W was 9s/slice and 20s/slice for T2W imaging. The effect of different MSDE preparation schemes on images was assessed by measuring SNR in the spinal cord (SC) and SNR in the sternocleidomastoid muscle (SM) (SNR=mean signal/standard deviation in the corresponding ROIs) and compared using paired t-test.

Contrast comparison: In all five subjects, conventional T1W and T2W DIR-TSE sequence were performed with the same FOV, slice thickness and acquisition matrix as 3D-MSDE-TFE. Acquisition parameters for T1W were TR/TE=1000/13ms, TI=600ms, TF=7, Half Scan Factor = 0.6, NSA=1, SF = 2, OS = 2 and TR/TE=3000/50ms, TI=865ms, TF=12, NSA=1, SF = 2.2, OS = 2 for T2W. Five slices were acquired positioned at the centre of 3D-MSDE-TFE imaging volume. Scan time was 17s/slice for T1W and 42s/slice for T2W. CNR measurements between spinal cord and sternocleidomastoid muscle (SC-SM) and sternocleidomastoid muscle and submandibular gland (SM-SG) were used to compare DIR-TSE and optimized MSDE. CNR measurements were performed at the same anatomical location for DIR and MSDE. Also CNR between sternocleidomastoid muscle and carotid artery lumen signal (SM-AL) was measured to assess the efficiency of blood signal suppression.

RESULTS: For the T1W MSDE optimization, SNR of RFP1 was higher than RFP2 (Fig. 2a). For the T2W, while there was no significant difference between RFP2 and RFP4, SM of RFP1 was significantly lower than SM of RFP2 or RFP4 (Fig. 2b). Based upon these results, we used RFP1 for T1W contrast comparison and RFP4 for T2W comparison with DIR-TSE. Contrast behavior of 3D-MSDE-TFE T1W and T2W acquisitions was similar to that of DIR-TSE, and there were no significant differences between the two methods (Fig. 3). The conventional and MSDE T1W and T2W images of the same location are shown in Fig. 4.

CONCLUSION: MSDE sequence has similar T1W and T2W contrast and blood suppression efficiency as compared to DIR-TSE, while the scan time is reduced by a factor of 2. Although clinical assessment of vessel wall visualization and plaque detection in patients is still needed, our results indicate that MSDE sequence is appropriate for multiple contrast 3D vessel wall imaging.

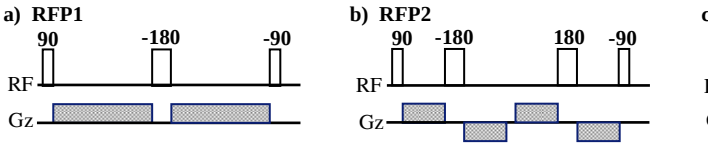

Fig. 1 : Three MSDE preparation sequences

Reference:

1. Koktzoglou I et al, JMRI 25:815-823 (2007)
2. Wang J et al, Proc. ISMRM 2007. p. 442
3. Nguyen T.D et al, Proc. ISMRM 2007. p. 3631
4. Levitt M et al, JMR 47:328-330 (1982)
5. Absil J et al, Proc. ISMRM 2007. p. 12

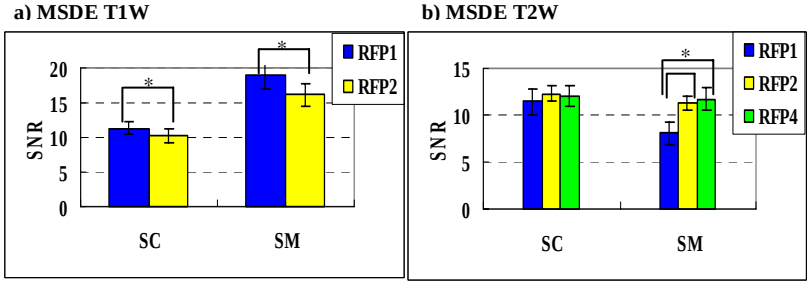

Fig. 2 : MSDE SNR comparison a) RFP1 and RFP2 comparison for T1W and b) RFP1, RFP2, and RFP4 comparison for T2W. * statistically significant difference (p < 0.05)

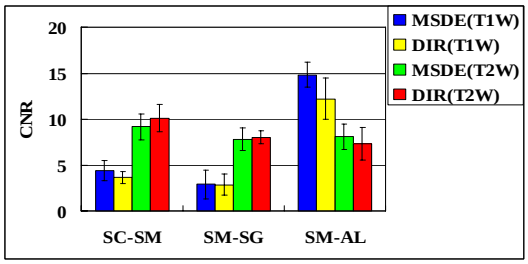

Fig. 3 : MSDE and DIR-TSE CNR comparison. There were no significant differences between MSDE and DIR.

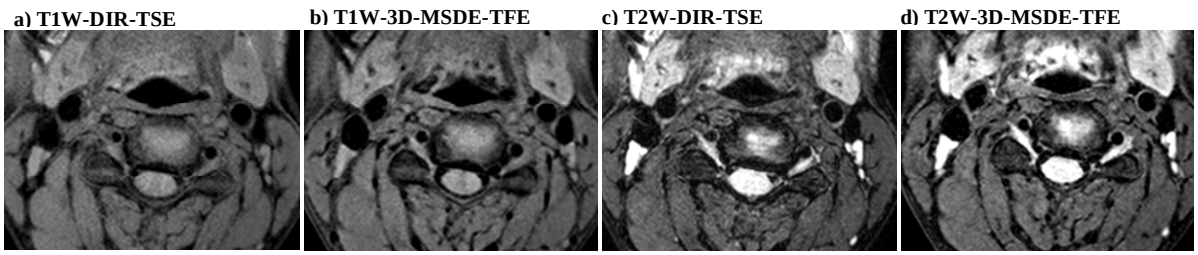

Fig. 4 : Comparison of T1W and T2W images with DIR-TSE and 3D-MSDE-TFE