3D flow-insensitive vessel wall imaging using T2PREP PSIR with SSFP

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Introduction Double Inversion Recovery (DIR) [1] and Flow Sensitive Dephasing (FSD) [2] have been used to suppress arterial signal in vessel wall imaging. However, the "black blood" effect of DIR and FSD depends on blood flow, which makes these techniques less effective with slow or in-plane flow. In this work, T1 and T2 differences between blood and vessel wall were exploited using a T2-prepared non-selective inversion preparation [3] for flow-insensitive vessel wall imaging. To alleviate the dependence of blood/vessel wall contrast on the choice of inversion recovery time (TI) and heart rate in ECG-triggered data acquisition, a Phase Sensitive Inversion Recovery (PSIR) [4] approach was used to achieve 3D flow-insensitive vessel wall imaging.

Theory Since blood and vessel wall have very different T1 and T2 values, a T2-prepared PSIR (T2PSIR) technique can provide excellent contrast. A composite pulse T2-preparation module was applied before the inversion pulse of PSIR to improve T2-weighted contrast. After the T2IR module, a 3D SSFP acquisition with a high flip angle (80°) was used to obtain maximal contrast between vessel wall and blood. Note that blood magnetization is negative. Therefore, phase-sensitive image reconstruction is required. To obtain reference phase information, another 3D SSFP acquisition with a low flip angle (8°) was played in the 2nd cardiac cycle after the same T2IR module delay time (Fig.1). Because the T2 preparation and inversion pulses are all non-selective, this technique provides flow-insensitive contrast. Note the magnitude of the vessel wall and blood after T2-preparation is opposite to that before T2-preparation because vessel wall has relatively shorter T2 compared to blood.

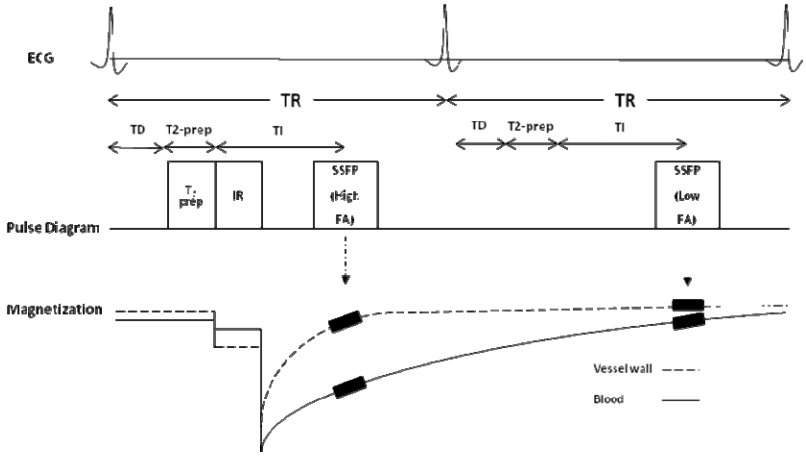

Fig. 1. Pulse diagram and magnetization change for T2PSIR with SSFP. SSFP with high FA was played following the T2PSIR module to acquire vessel wall images, and SSFP with low FA was played in the subsequent cardiac cycle to acquire the phase reference data.

Methods The superficial femoral arteries were imaged using this technique in 12 healthy subjects (9 Male, 3 Female) on 3.0T (MAGNETOM Trio, Siemens) using a 12-channel body coil array and spine coils. An ECG-triggered, T2PSIR-prepared, 3D segmented SSFP sequence was used for acquisition. Parameters used were: TR/TE = 3.6/1.8 ms, TI = 250 msec, T2preparation time = 40 ms, flip angle = 80°, resolution = 0.7 x 0.7 x 2.0 mm^3, 32 slices, transversal view, 30 k-space lines per cardiac cycle, bandwidth = 610 Hz/pixel with GRAPPA acceleration factor of 2. CNR between vessel wall and lumen, lumen and vessel wall areas were compared in 7 volunteers between this technique and conventional DIR-TSE (double inversion recovery – turbo spin echo).

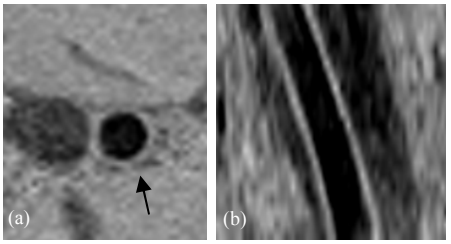

Fig. 2. (a) Cross-sectional view of one volunteer. (b) MPR image reformatted from the same volunteer. Note the clear depiction of the superficial femoral artery wall (arrow).

Results Fig. 2 shows one axial slice of a volunteer and the MPR image from the 3D data. Clear depiction of the superficial femoral vessel wall can be found both on the original image and MPR with complete suppression of the blood signal. Fig. 3 shows the comparison of vessel wall imaging between T2PSIR SSFP and DIR-TSE. Table 1 shows the quantitative evaluation results. CNR between vessel wall and lumen significantly increased compared to DIR-TSE ($p < 0.001$). Lumen and vessel wall areas of the two techniques were in a good agreement based on intraclasss correlation coefficients (0.975 and 0.937, respectively; $p < 0.001$ for both).

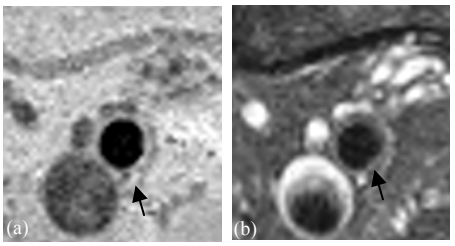

Fig. 3. Cross-sectional views of the vessel wall (arrows) using (a) T2PSIR SSFP and (b) DIR-TSE.

Discussion and Conclusions We developed a new technique for 3D flow-insensitive vessel wall imaging. This technique can acquire 32-slices in approximately 4 minutes and has substantially improved imaging efficiency over single-slice DIR-TSE. More importantly, it is flow and TI-insensitive because of PSIR preparation. This technique is particularly useful for vessel wall imaging in the peripheral arteries because of the relatively slow flow.

References 1. Edelman RR, et al. Radiology 1991:181:655-660. 2. Koktzoglou I, et al. JCMR 2007; 9:33 3. Liu CY, et al. ISMRM 2008, p3079. 4. Zuehlsdorff S. ISMRM 2007, p2530.

	CNR	Lumen (mm^2)	Wall (mm^2)
DIR-TSE	3.60 ±1.83	0.38±0.14	0.28±0.09
T2PSIR	9.10 ±3.55	0.39±0.14	0.26±0.08
ICC agreement	N/A	97.49%	93.73%

Table 1. CNR and morphological measurement comparisons between DIR-TSE and T2PSIR