

Comparison of Black-Blood Magnetization Preparation Techniques for 3D Vessel Wall Imaging in the Lower Extremities

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INTRODUCTION: Conventional black blood (BB) MRA techniques rely on inflow of saturated upstream blood into an imaging plane, eg. Double Inversion Recovery¹ (DIR) and Spatial presaturation² (SpSat). While these techniques are effective for obtaining 2D submillimeter resolution images of arteries with fast-flowing blood such as the aorta, they are less effective for 3D imaging. Recently, several approaches have been developed to provide improved blood suppression for 3D imaging, including Motion-sensitizing magnetization preparation³ (MSprep), which nulls blood using velocity-encoding gradients; and T2-prepared Inversion Recovery⁴ (T2prep-IR), which enhances contrast of materials with similar T1 but different T2 and provides flow insensitive blood suppression⁵. In this study, a comparison of these four black-blood magnetization preparations was performed for 3D SSFP imaging of the proximal popliteal artery BB MRA.

METHODS: 11 healthy volunteers (7 male, age=29±4 years) were scanned using an 8-channel knee coil for signal reception. Each preparation technique was optimized using a 2D axial prescan to calibrate the TI time for DIR and T2prep-IR; the saturation flip angle for SpSat; and the field of speed (FOS) for MSprep. 3D axial views of the popliteal artery were acquired using peripherally gated (1R-R) SSFP sequence using the four magnetization preparations on a GE Signa 1.5T scanner with the following scan parameters: TR 3.3-4.5 ms, TE = 1.6ms, flip angle 60°, 256x256x32, receiver bandwidth 83.3 kHz, FOV=16.0cm x 16.0cm x 9.6cm, NEX=2, VPS=64, slice thickness=3.0mm reconstructed to 1.5mm, with a scan time of 4 minutes for a nominal heart rate of 60bpm. Spectrally selective fat saturation was also applied before image acquisition. 2D phase contrast MRI was also performed to measure blood velocity and flow rate. Tissue and lumen signal-to-noise-ratio (SNR) and contrast-to-noise-ratio (CNR) was measured at the 2.5cm, 5cm, and 7.5cm slice of the 3D volume, and an experienced radiologist scored each 3D image as 0=very poor, 1=poor, 2=fair, 3=good, 4=very good; for blood suppression and vessel wall depiction. Student's t-test and Wilcoxon's Rank-sum tests were performed between MSprep and T2prep-IR for measurements and assessment scores, respectively.

RESULTS: Figure 1 shows a reformatted view of the vessel wall for each magnetization preparation, along with the axial slices of the vessel wall. In DIR and SpSat images, black blood effect penetrated less than half way into the 3D volume. MSprep and T2prep-IR images provided consistent blood suppression throughout and clearly depicted the vessel wall across the volume. PC flow measurements yielded a mean blood flow 44±39 mL/min, and peak blood velocity of 24±9 cm/s. Both MSprep and T2prep-IR prepared 3D SSFP images yielded excellent blood suppression in terms of lumen SNR, CNR, and received high scores on the assessment (Table 1). T2prep-IR and MSprep also both yielded lower wall/tissue SNR than DIR or SpSat. Aside from the presence of ghosting artifacts in MSprep images (Figure 2), and slightly better performance of T2prep-IR in terms of lumen suppression, both T2prep-IR and MSprep results were statistically comparable.

DISCUSSION: Both MSprep and T2prep-IR provided excellent blood suppression and vessel wall characterization across an entire 3D volume, while the black blood effect of DIR and SpSat penetrated only partially into the 3D volume. T2prep-IR provided equivalent blood suppression and less ghosting artifacts than MSprep; These BB MRA techniques show promise in providing high-resolution imaging of the lower extremity vessel wall with excellent coverage, which may be useful for vascular diagnosis, surgical planning, and monitoring plaque burden.

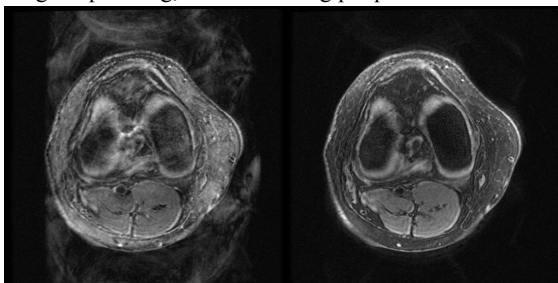


Figure 2. L) Axial MSprep showing ghosting; R) T2prep-IR.

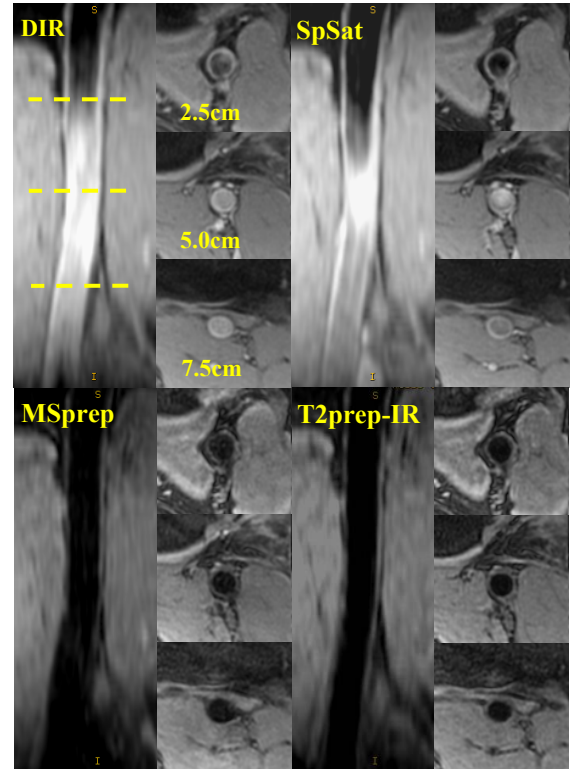


Figure 1. Reformatted views of the popliteal artery and axial cross-sections at 2.5, 5, and 7.5cm slices from superior end for (clockwise, from top left) DIR, SpSat, T2prep-IR, and MSprep.

Table 1 Statistical summary of 11 volunteer scans using four BB preparations.

	DIR	SpSat	MSprep	T2prep-IR
Optimized Prescan Parameters	TI = 370±81ms	FA = 111±9°	FOS = .02±.01 cm/s	TI = 239±38ms
Measured Values				
Lumen SNR at 4cm	41±26	36±17	15±3	10±3
8cm	105±41	137±40	18±5	11±3
12cm	101±26	106±37	13±2	8±2
CNR at 4cm	76±35	86±27	57±30	39±8
8cm	29±43	15±27	59±20	48±13
12cm	18±28	28±35	54±22	42±9
Assessment Scores				
Blood Suppression	2.3±1.2	2.7±1.2	3.9±0.3	3.8±0.4
Vessel Wall Depiction	1.5±0.9	2.2±0.6	3.4±0.9	3.3±0.5

* **BOLDFACE** indicates no statistical difference was found (p > 0.05).

References: 1. Edelman et al. Radiol. 1991; 181:1-11. 2. Felmler et al. Radiol. 1987; 164:559-564. 3. Koktzoglou et al. JCMR 2007; 9:33-42. 4. Brittain et al. MRM 1997; 38:591-603. 5. Nguyen et al. Proc. ISMRM 09 pp 607.