Three-dimensional T2-weighted TSE MRI of the Human Femoral Arterial Vessel Wall at 3.0Tesla

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Introduction: Peripheral artery disease (PAD), affecting approximately 12 million people in the US, is a condition that results in poor circulation in the legs. Magnetic resonance imaging (MRI) could be used for the non-invasive assessment of atherosclerotic plaque burden in the peripheral circulation. Typically 2D dark blood turbo spin-echo (TSE) techniques are used for femoral arterial wall imaging (1). However, 2D techniques require prolonged imaging time to cover a large region of interest in the leg. Recently, variable-flip-angle 3D TSE T2-weighted (SPACE) has been introduced as a dark blood technique for fast imaging of vessel wall (2, 3) at 1.5T. The purpose of our study was to evaluate and translate this technique for assessing atherosclerotic disease of the superficial femoral artery (SFA) at 3.0T.

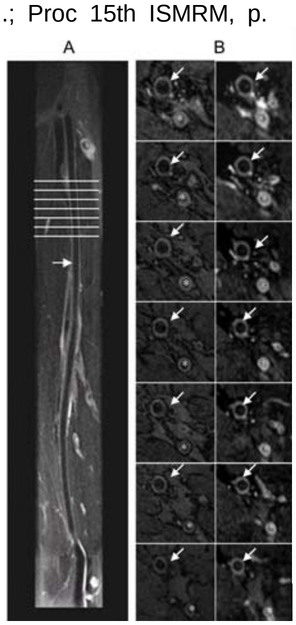
Materials and Methods:

Fifteen healthy volunteers underwent MR scans on a 3.0T scanner (Tim Trio, Siemens, Erlangen, Germany) using a body phased-array coil. SPACE imaging parameters were as follows: coronal acquisition covering both SFAs, TR/TE = 1500/198 ms, number of averages = 2, number of slice = 89, FOV = 380 x 380 mm^2, turbo factor=49, resolution 0.7 x 0. 7 x 0.7 mm^3, TA = 11 min. After multi-planar reformatting (MPR) of 3D images to obtain cross-sectional orientations, 2D T1-, T2-, and PD-weighted multi-slice black-blood TSE acquisitions with inflow/outflow saturation bands were run with 7 interleaved slices (3 mm thickness, 100% interslice gap) per acquisition and a total of 10 acquisitions to cover 380 mm of SFA (1). Image resolution was 0.5 x 0.5 x 3 mm^3. Cross-section images of SFA were reconstructed from 3D data by MPR. For each subject, each pair of 2D axial slices of 3D SPACE and 2D TSE were analyzed using ImageJ (version 1.37v, NIH, USA) to measure signals of vessel wall, lumen, and muscle. Muscle-lumen (ML) contrast-to-noise efficiency (CNR_{eff}) was compared between 2D and 3D scans. Statistical comparison was performed by means of a Student's *t*-test with a $p<0.05$ to indicate significance.

Results: A sample image slice obtained from one subject is shown in Fig.1. Muscle-lumen CNR was significantly higher with 3D SPACE when compared with the reference standard: 2D T2w TSE (3.12 ± 0.84 vs. 2.17 ± 0.34, p < 0.01). This trend was confirmed when CNR efficiency (CNR_{eff}) values were compared between SPACE and 2D T2w TSE. The measurements of wall volume (WV) and lumen volume (LV) by SPACE and 2D T2w TSE were highly correlated (WV: linear regression $r^2 = 0.981$, LV: $r^2 = 0.991$, $p < 0.001$ for both) and Bland and Altman plot of the percentage difference in SFA LV versus average SFA WV showing the limits of agreement in Fig. 2. For the acquisitions of 2D multi-slice T2-weighted scan, around 40 minutes are required for coverage of SFA. The 3D SPACE method has a much shorter imaging time of 11 minutes to cover the same anatomic area.

Discussion and Conclusion: The results show that 3D vessel wall imaging of the SFA with the SPACE technique is feasible. In patients, isotropic resolution SPACE images with the aid of MPR may show plaque in any orientation, which is not possible with 2D TSE. This is particularly true along the vessel's long axis, which provides an overview of wall morphology and plaque burden. In addition, SPACE imaging was more time efficient as compared to 2D multislice TSE (3D vs 2D, 11 vs 40 minutes) and allowed for an adequate spatial coverage of the SFA with high resolution. This method may be applicable to longitudinal drug development studies where plaque composition and volume are important end points.

References: [1] Isbell DC et al.; J Cardiovasc Magn Reson. 2007; 9:71-76. [2] Chung et al.; Proc 14th ISMRM, p. 653, 2006. [3] Mani et al.; Proc 15th ISMRM, p. 683, 2007.



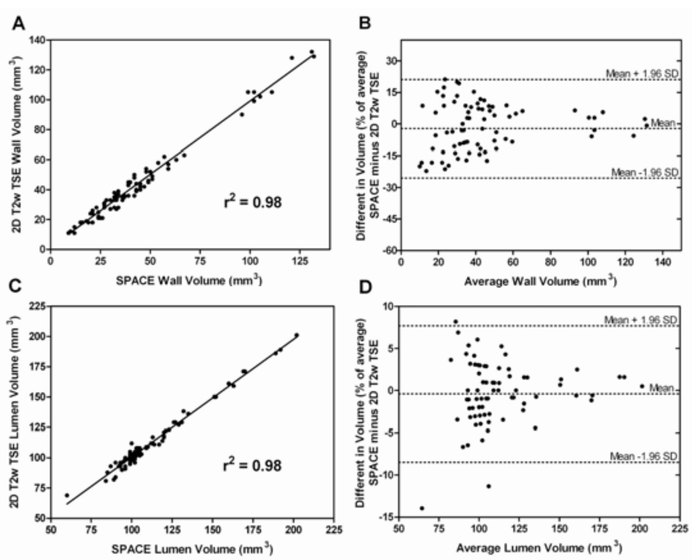


Fig.1 Left: Curved MPR image shows the longitudinal view of SFA acquired using SPACE on panel A. Panel B (left) shows 7 axial slices of 2D T2w TSE images of SFA from line mark on panel A, Panel B (right), the pairs of 3D SPACE cross-sectional images created by MPR, arrow points SFA

Fig.2 Right A: scatter plot of SFA WV in the healthy volunteers as measured by SPACE and 2D T2w TSE images; linear regression r2 = 0.981; p < 0.001. B: Bland and Altman plot of the percentage difference in SFA WV versus average SFA WV showing the limits of agreement. C: scatter plot of SFA LV in the healthy volunteers as measured by SPACE and 2D T2w TSE images; linear regression r2 = 0.979; p < 0.001. D: Bland and Altman plot of the percentage difference in SFA LV versus average SFA WV showing the limits of agreement.