Development of a dark blood MRI protocol for femoral plaque imaging

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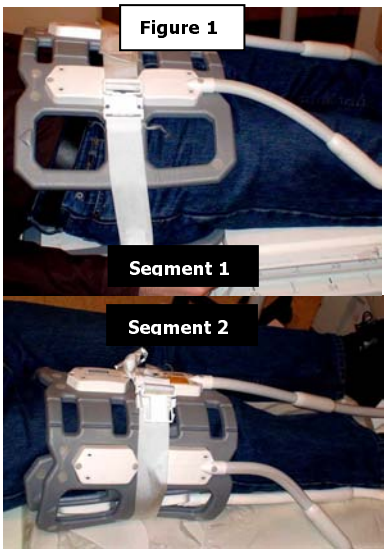
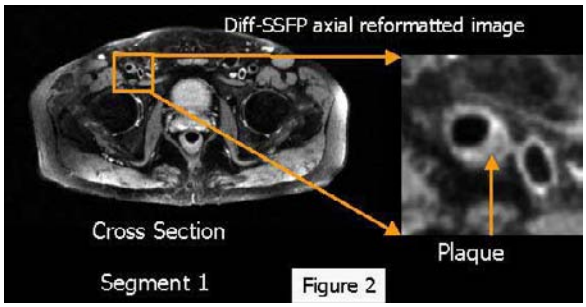
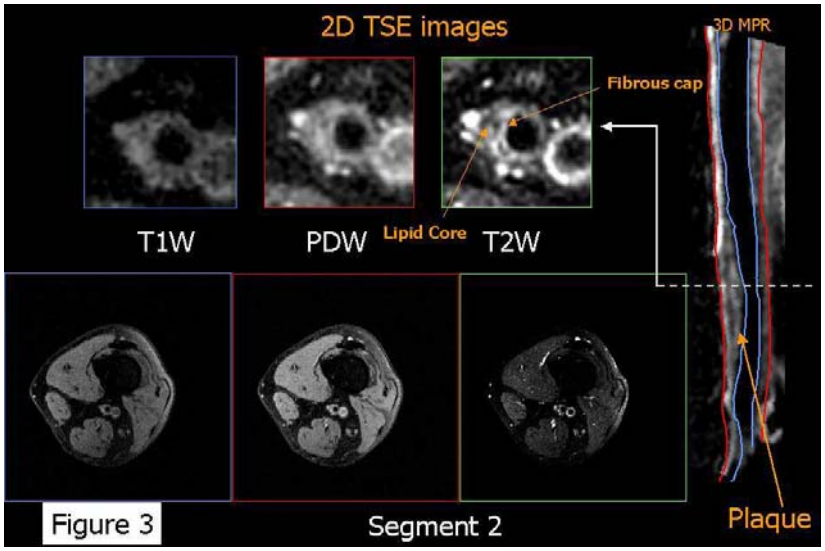
Introduction: Peripheral artery disease (PAD) in femoral arteries is typically assessed by angiographic techniques. Due to positive remodeling effects of atherosclerosis, burden of disease is underestimated by angiography. Black Blood MR imaging offers a convenient method for evaluating both plaque burden and composition in PAD. Typically 2D black blood turbo spin echo (TSE) sequences are obtained using different contrast weightings to evaluate plaque composition. Partial volume averaging artifacts however limit the use of 2D imaging for assessment of plaque burden in vivo. Recently, fast 3D black blood sequences have been developed to overcome this limitation including a) Diffusion SSFP [1] and b) variable flip angle TSE (SPACE) [2] for vessel wall imaging. The disadvantage of these 3D techniques is the fact that they provide limited information regarding plaque composition and long scan times. The purpose of this study was to integrate the advantages of both 3D acquisitions (anatomical coverage, ability to reformat images in any given plane, and reduced partial voluming artifacts) along with the advantages offered by multiple contrast weightings possible with 2D dark blood TSE imaging to develop a protocol for femoral plaque imaging.



Methods: 5 healthy volunteers and 5 atherosclerotic patients were subject to femoral imaging on a 1.5T Siemens scanner. The scan was divided into 2 segments for greater anatomical coverage. In the first segment, peripheral arteries extending from the level of the iliac bifurcation to the level of the bifurcation of the femoral artery (into superficial and deep) was imaged. In the second segment, the whole extent of the femoral artery up to the beginning of the politeal arteries was imaged. The 6 channel cardiac anterior and 6 channel posterior phased array coils were used for imaging as shown in Figure 1 for segments 1 and 2 respectively.



After tri-plane localizers, 3D dark blood imaging was performed using both the SPACE and the Diffusion SSFP sequences. Imaging parameters were as follows: Diff SSFP sequence: 32 coronal slices 0.97mm thick (interpolated to 0.5 mm) were obtained with a matrix size of 768 x 504 (interpolated) pixels and a field of view (FOV) of 40 x 26.2 cm^2. TR/TE was 370ms /1.9ms. 65 segments and a flip angle of 30° were used. The echo spacing was 4.3ms. For the diffusion module, the B-Value used was 0.6042 s/mm2. SPACE sequence: 48 coronal slices 0.9 mm thick were obtained with a matrix size of 192 x 176 pixels with a FOV of 25 x 22.8 cm^2. The TR/TE/echo train length was 500ms/115ms/57. Image acquisition time was approximately 5 minutes for each sequence. After 3D multi-planar reformatting (MPR) of images, 2D dark blood TSE images using inflow/outflow saturation bands, perpendicular to the femoral artery being imaged were obtained using T1- weighted (7 slices, 3mm thickness, TR/ TE = 800/ 5.2 ms, matrix size = 320 x 320, FOV = 18 x 18 cm^2), PD-weighted (31 slices, 3mm thick, TR/ TE= 3500/ 5.2 ms, matrix size = 320 x 320, FOV = 18 x 18 cm^2), and T2-Weighted images (31 slices, 3mm thick, TR/ TE = 3500/ 52 ms, matrix size 320 x 320, FOV = 18 x 18 cm^2). An experienced observer subjectively assessed image quality and interpretability. An expert also determined presence, absence and composition of atherosclerotic lesions.



Results: Sample images obtained from an atherosclerotic patient are shown in Figures 2 and 3. Figure 2 shows images obtained using the Diffusion SSFP sequences, reformatted in the axial plane from segment 1. Figure 3 shows a 3D MPR of a section of femoral artery containing plaque using the SPACE sequence and corresponding 2D images of the plaque using dark blood TSE sequence of different contrast weightings. The 2D multi–contrast TSE images were used for plaque classification [3]. The Diff-SSFP provided T1/T2 contrast and the SPACE sequence could be modified appropriately (increased TR to > 2000) to provide T2 weighted images in 3D. With the above-described protocol, all images obtained were deemed to be of acceptable image quality for clinical interpretation. None of the 5 volunteers scanned had atherosclerotic lesions in the femoral artery segments imaged. 3 of the 5 patients at risk for atherosclerosis had significant burden of disease (at least 1 lesion with > 30% stenosis in the imaged segments). Complex lesions were observed in 2 of the 5 patients.

Conclusions: A combination of 3D and 2D dark blood sequences can be successfully used to evaluate burden and composition of atherosclerotic disease in femoral arteries.

References:

[1] Koktzoglou et al.; Proc 14th ISMRM, p.652, 2006.
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[3] Itskovich et al ; Magn Reson Med. 2004 Sep;52(3):515-23.