3D Dark-Blood SSFP For Carotid Artery Wall Imaging

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Introduction: In order for MRI to reliably detect and characterize carotid atherosclerotic plaque, the imaging sequence should yield high spatial resolution and signal-to-noise ratio (SNR), and allow for adequate coverage in a reasonable imaging time. 2D multi-slice turbo spin-echo (TSE) techniques have efficient spatial coverage, but lack spatial resolution in the slice direction. While 3D TSE can improve slice resolution, it suffers from long imaging times, high SAR, and blurring due to T2-decay [1,2]. The purpose of this work was to demonstrate that 3D dual-inversion prepared steady-state free precession (SSFP) allows for high resolution dark-blood imaging of the carotid artery wall, with adequate coverage in a reasonable imaging time.

Materials and Methods: Carotid wall imaging using a 30 mm thick slab was performed in 8 healthy volunteers (7M/1F, mean age = 34 yrs) in a 1.5T scanner (Sonata, Siemens Medical Systems, Erlangen, Germany) with a 4-channel carotid coil (Machnet BV, The Netherlands). The imaging sequence (Figure 1) consisted of a double inversion-recovery (DIR) preparation followed by SSFP data acquisition (TR = 1s, FOV = 12×12 cm^2, matrix = 256×256, in-plane resolution = 0.47×0.47 mm^2, slab thickness = 30 mm, 20 slices interpolated to 30, slice oversampling = 20%, NEX = 2, imaging time = 3m17s). Data acquisition (TR/TE = 5.8/2.9 ms, 65 lines, flip angle = 45°, centric k-space ordering) was preceded with a fat saturation pulse and linear flip angle (LFA) preparatory pulses [3].

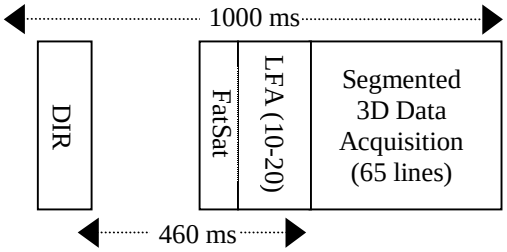

Figure 1. Timing diagram of the 3D dark-blood SSFP imaging sequence.

Results: Excellent blood suppression was achieved in all subjects with the 3D black-blood SSFP technique. As with other carotid MR imaging techniques, however, residual blood signal was sometimes seen in the carotid bulb. Images acquired with this technique and multi-planar reconstructions are shown in Figure 2. Clear visualization of the carotid wall was achieved over the entire 30 mm slab. Moreover, both carotid arteries could be imaged simultaneously (Figure 3). SNR was calculated by dividing tissue signal by the standard deviation of the air signal. Mean SNR of the carotid wall was 16.0±4.9 and mean wall-lumen CNR was 11.8±4.7.

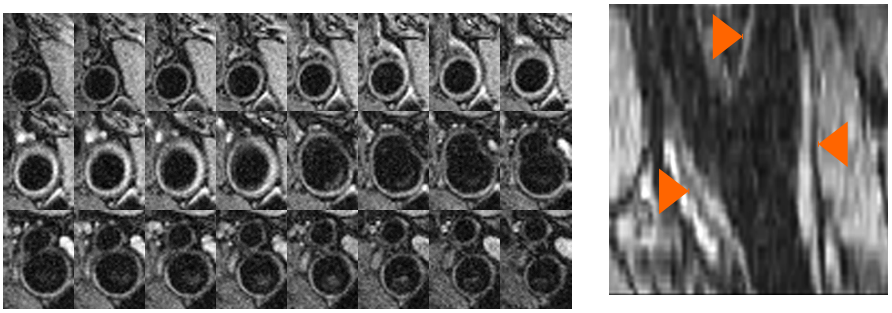

Figure 2. Original images acquired with the 3D dark-blood SSFP technique (left). A multi-planar reconstruction (right) delineates the carotid artery wall (arrowheads).

Conclusion: The presented dark-blood 3D SSFP sequence provided clear visualization of both carotid artery walls over 30 mm in a reasonable imaging time of 3m17s. This technique allows for rapid assessment of carotid artery wall morphology, and may ultimately allow for rapid detection of the presence of carotid atherosclerotic plaques. High through-plane resolution and the ability to apply multi-planar reconstruction allow in-plane visualization of the arterial wall. Further patient studies are warranted to investigate the signal and contrast behavior of plaque components with this SSFP imaging technique.

References:

[1] Crowe LA et al. JMRI 2003;17:572-80
[2] Yarnykh VL et al. ISMRM 2003; #1632
[3] Deshpande VS et al. MRM 2003;49:151-7

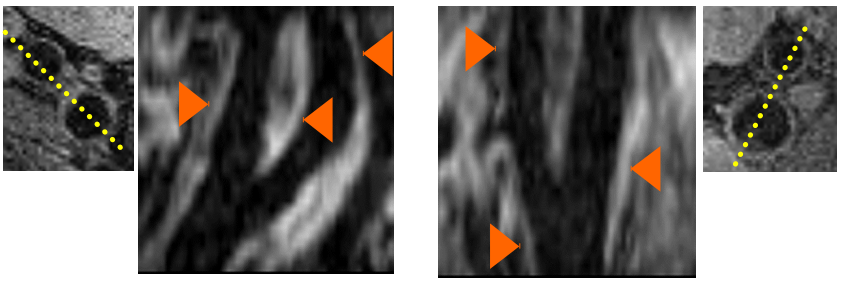

Figure 3. Multi-planar reconstructions through the left (left) and right (right) carotid bifurcations from a single 3D slab acquired using dark-blood SSFP in 3m17s. Arrowheads indicate vessel walls.