Fast 3D Reduced Field of View Carotid Imaging at 3T

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Introduction: Multi-contrast high-resolution imaging can be used to identify and characterize atherosclerotic carotid plaque. Standard protocols use 2D multi-slice fast spin echo (FSE) pulse sequence with double inversion recovery (DIR) preparation for blood suppression [1]. These techniques have long scan times and require multiple averages to boost SNR at 1.5T. Scan time reduction can be achieved by interleaving multiple slices [2], reducing the FOV in the phase-encoding direction by applying the excitation and refocusing on orthogonal spatial axes (rFOV) [3] or a combination of both [4]. These techniques suffer an SNR penalty proportional to the square root of the scan-time reduction factor. In this work, we incorporate 3D encoding which provides a substantial boost in SNR, and demonstrate 3D rFOV imaging with a factor of four reduction in scan time compared to conventional techniques. The surplus SNR associated with 3D encoding allows for the use of parallel imaging, which further reduce the number of required phase encodes. A similar 3D rFOV method was demonstrated at 1.5T by Crowe et al. [5] but with a minor reduction in the phase encoding-FOV and without parallel imaging.

Methods: Three-dimensional reduced field of view FSE was implemented. Slab selection axes for the refocusing (slice encoding axis) and excitation (phase encoding axis) pulses were chosen to minimize the echo spacing and maximize readout duty-cycle. Blood suppression was achieved using the conventional DIR method and consisted of a 1ms non-selective hard pulse and 8.6ms selective adiabatic hyperbolic secant pulse. To improve the vessel wall delineation, fat saturation was applied prior to data acquisition. A 4-channel carotid array coil was used for signal reception and phase/frequency encoding directions were chosen so as to maximize the coil sensitivity variation along the phase encoding axis.

Experiments were performed on a GE Signa Excite 3T scanner equipped with high-speed gradients and receiver. All scans were cardiac gated with parameters: TE = 5ms, TR = 1 R-R, ETL = 10, receiver bandwidth = ±125kHz, ESP = 5.1ms, TI = 350ms (for heart rate = 75bpm). Three volume datasets were obtained in each subject: 2D 8-slice full FOV (conventional), 3D rFOV, and 3D rFOV + SENSE (reduction factor = 2). All datasets were acquired with 0.5 x 0.5 x 2.5 mm^3 resolution. The slice thickness for conventional 2D imagin was 2.5mm and the slab thickness for 3D imaging was 25 mm along phase encoding axis and 16 mm along the slice encoding axis. The field of view was 16x16cm^2 for the conventional scan, and was 16x6.4x2cm^3 for the rFOV scans. The reconstructed matrix sizes were 320x320x8 for conventional, and 320x128x8 for rFOV and rFOV + SENSE. The total scan time for the conventional technique was 210 seconds, rFOV was about 84 seconds and for rFOV + SENSE technique was 42 seconds. Low-resolution sensitivity maps were acquired prior to imaging.

Results: Figure 1 contains a single T1-weighted slice of the carotid arteries just above the bifurcation from a healthy volunteer. The 3D images show comparable blood suppression with respect to the conventional technique. The computed vessel wall SNR was 35 and 66 for 3D rFOV + SENSE and 3D rFOV respectively, and was 32 for conventional 2D imaging. Most of the SENSE related artifacts were confined to the edges (box) of the excited y-slab due to inaccuracies in the sensitivity map. The g-factor associated SNR loss in the region of interest was minimal. The SENSE related artifacts became significant with more aggressive reduction in the FOV (<5cm).

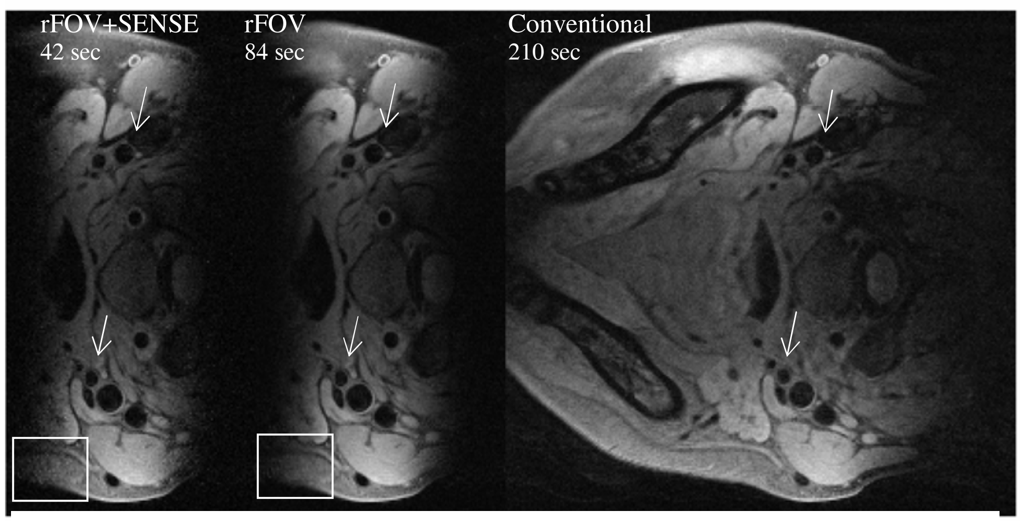

Figure 1: T1-weighted images at the carotid bifurcation. The 3D reduced FOV images with and without SENSE acceleration have comparable quality to images from conventional 2D images.

Discussion: We demonstrate a 42-second acquisition of 3D carotid vessel-wall datasets with 0.5x0.5x2 mm^3 resolution over a 16x6.4x2cm^3 FOV, with vessel wall SNR > 35. 3D acquisitions are combined with reduced FOV acceleration and parallel imaging. The reconstructed image quality was comparable to that of conventional multi-slice methods in less than 20% of the scan-time. This approach can also be applied to proton-density and T2-weighted FSE vessel wall imaging.

[1] Yuan et al. JMRI 1994; 4 : 43-49 [2] Kim et al. MRM 2004; 52 : 1379 [3] Conturo et al. MRM 938; 6 : 418-429
[4] Kim et al. ISMRM 2006; 14 : 2168 [5]Crowe et al. JMRI 2003; 17 : 572-580

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Multi-contrast high-resolution imaging is used to characterize carotid plaque components. Standard multi-slice methods have long scan times and require multiple averages to boost SNR. We demonstrate a time and SNR efficient 3D reduced FOV technique in conjunction with parallel imaging. Cardiac gated 3D carotid vessel-wall datasets with 0.5x0.5x2.5 mm^3 resolution over a 16x6.4x2cm^3 FOV, and vessel wall SNR > 35, were obtained in 42 seconds. Resulting images have comparable quality relative to conventional 2D multi-slice imaging and were obtained in a fraction of the time.