Carotid Plaque Imaging at 1.5T and 3T: Systematic SNR Comparison

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Introduction: High-resolution plaque imaging allows characterization of atherosclerotic plaque. However, increasing image resolution results in lower SNR or longer scan times. 3T whole-body MRI systems with high-speed gradients may provide the additional SNR to improve spatial resolution or reduce scan time, which can be long for a multi-contrast carotid imaging protocol (1). Therefore, we have adapted our dedicated phased-array carotid coil design (2) and our multislice double inversion-recovery (DIR) black-blood imaging sequence to 3T (3). Here we present our systematic comparison of SNR for 1.5T vs 3T for carotid plaque imaging using multiple contrast weightings and spatial resolutions.

Methods: Six healthy subjects (5M, 1F, age 26-43) and 3 patients with advanced carotid atherosclerosis (2M, 1F, age 59-79) participated in the study. All subjects were imaged on both a 1.5T (Signa Twinspeed) and a 3.0T (Signa VH/i) whole body system (GE Medical Systems, Milwaukee, WI) equipped with high-performance gradients (40mT/m, 150mT/m/msec). We used a customized four-element phased-array surface coil on both scanners (2). The protocol consisted of 3 different contrast-weighted black-blood FSE sequences, including T1, T2, and proton density (PD) [TR/TE/echo train: 800/10/10 for T1, 2500/50/12 for T2, and 2500/9/12 for PD scans, FOV = 14-16cm, slice thickness = 2mm]. For the long TR sequences (PD- and T2-weighted), the multislice DIR method was used with 4 slices per TR. T1-weighted images were obtained using single-slice DIR. Inversion times were adjusted based on the blood T1 (1.5 T: 1200ms, 3T: 1550 ms). Three different matrix sizes (256x256, 384x384, 512x512) were used to achieve increased spatial resolution, as well as NEX=1 and NEX=2. SNR was measured from the average of left and right sternocleidomastoid muscles. SNR was also measured from the same ROI (region-of-interest) within plaque with all different sequences. Statistical comparison between 1.5T and 3T was performed with a paired Student t-test.

Results: Overall SNR of the sternocleidomastoid muscles increased by 54% at 3T compare with 1.5T. SNR was significantly increased at all 3 contrast weightings and matrix size (Figure 1). Figure 2 shows images at both 1.5T and 3T of an eccentric fibrous plaque with all 3 contrast weightings, demonstrating the improved SNR at 3T. Figure 3 shows images of a more concentric calcified plaque, demonstrating low signal in the calcium compared to fibrous regions. The average plaque SNR increase was 61% for the high-signal fibrous plaque and 11% in the low-signal calcified plaque.

Discussion/Conclusion: For multi-contrast carotid imaging sequences, we have demonstrated a substantial improvement in SNR at 3T across a wide range of imaging parameters. While not as high as the 2-fold increase expected for doubling the field strength, the SNR increase was similar to our prior data for coronary MRA, where the overall increase in SNR at 3T was 47% (4). Further optimization and experience with 3T carotid plaque imaging may improve SNR further. In addition, further investigation of signal characteristics at 3T for different plaque components is required. In conclusion, 3T provides higher SNR for multi-contrast carotid plaque imaging, which may allow improved characterization of carotid plaque.

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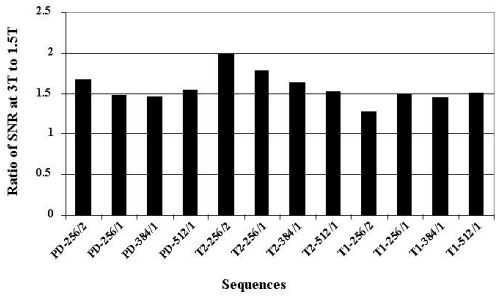

Figure 1: SNR ratio for 3T vs. 1.5T for multiple contrast weightings (PD/T2/T1), matrix sizes (256/384/512) and NEX (2/1). SNR was significantly higher for each comparison ($P<0.05$).

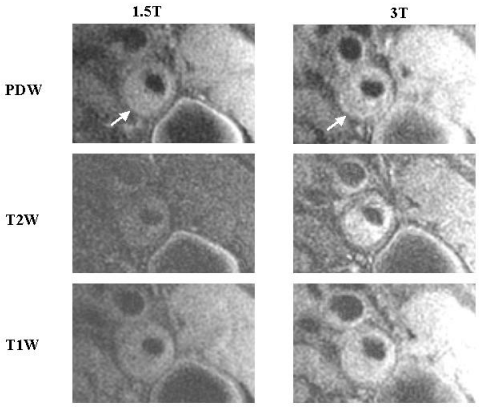

Figure 2: Multi-contrast images of an eccentric fibrous plaque (arrow) with the identical window/level settings. The SNR is clearly increased at 3T. [matrix size=384x384, NEX=1]

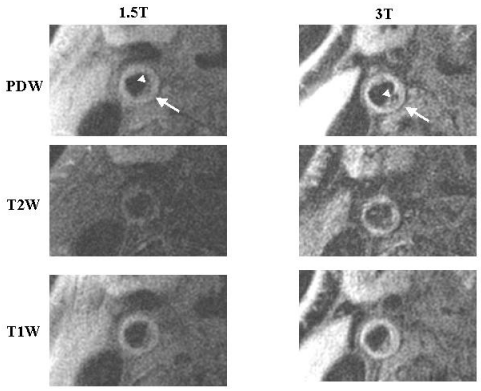

Figure 3: Multi-contrast images of a calcified plaque (arrow). Overall SNR is clearly improved at 3T, but the signal remains low in the calcified region (arrow head). [matrix size=384x384, NEX=1]