Quantitative 3.0 T Carotid Plaque Imaging

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Objective

The aim of this work is to assess the impact of 3.0T on the quantitative analysis of carotid atherosclerotic plaque images. We were interested in comparing the test-retest measures of vessel wall area, plaque area and composition obtained from 3.0 T multi-contrast black blood and post-GdDTPA T1W images. The overall research endeavor is to provide biomarkers on the stage and stability of atherosclerotic disease for clinical decision making and therapeutic agent trials.

Introduction

While extensive development has been performed at 1.5T for atherosclerosis imaging of multiple vascular beds, only recently has the application been reported at 3.0T for carotid plaque imaging[1,2]. The motivation for 3.0T is straightforward in that the SNR gain is applied to improving spatial resolution and reducing signal averaging requirements, which we hypothesize will improve quantitative image analysis and reproducibility compared to 1.5T.

Methods

Seven subjects both male and female ranging in age from 22 to 76 participated upon giving informed consent with all studies conducted according to institutional IRB guidelines. All subjects were imaged on a 3.0T Siemens TRIO using an in-house constructed dual array receiver coil. The parameter ranges for axial unilateral carotid images using double inversion (black blood) TSE were 9-13 ETL, 10 -12 cm FOV, 256 x256 matrix, ECG trigger 1 to 3 R-R's trigger (0.7-2.8 s TR), TE= 10-12 (T1, PD) and 40-50 (T2) ms. EKG triggering was used for all black blood scans and the double inversion time delay varied in the range of 400-600 ms and 200-300 ms (post GdDPTA) depending on heart rate. Bright blood MRA was acquired with a rapid 3D TOF sequence and the contrast dose for all studies was 0.1mmol/kg of contrast. Two independent readers performed image analysis using both manual and semi-automated segmentation routines.

Results

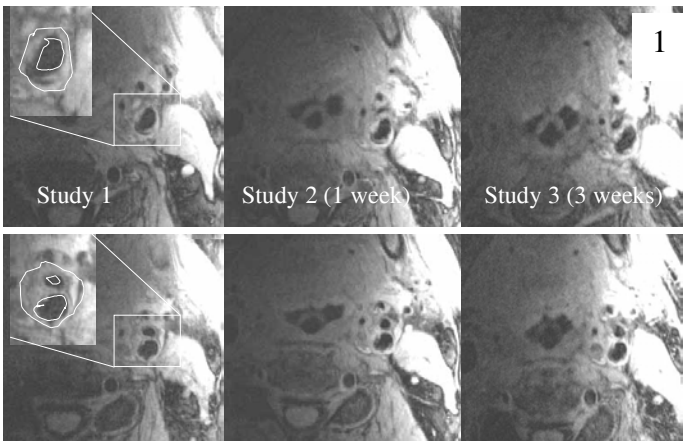

Figure 1. 3.0 T PDW black blood axial images of moderate plaque (2 mm slice, 0.4 mm in plane). Series shows two slice locations with plaque taken over three time points.

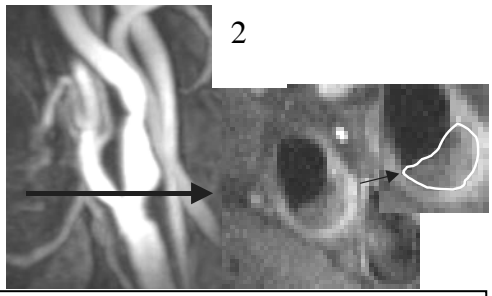

Figure 2. 3.0 T MRA and axial post GdDTPA black blood image showing plaque with large lipid core with area reproducible (within 8%) at second time

Figure 1 shows 3.0 T axial images at two locations along the bifurcation in a 76 year old with moderate atherosclerosis. The images were acquired over three time points in three weeks and show qualitative reproducibility. The total plaque volume was calculated from four contiguous slices in which the plaque area was measured by segmenting the inner lumen and outer wall boundaries. Over the three time points, total plaque volume calculated for each contrast (T2W, PD, T1W) was in agreement within 4.9 – 11.9%. The T2W image with the highest contrast to noise for the outer wall boundaries had the lowest variability and T1W the highest. Figure 2 shows for a 43 year old male with Type I diabetes and advanced atherosclerosis, 3.0 T GdDTPA enhanced MRA of the bifurcation region and a subsequent delayed enhanced axial T1W black blood image in the bifurcation. The large region of plaque that did not enhance is consistent with the presence of necrotic lipid core and this contrast pattern has been well described at 1.5T[3]. A repeat identical scan session was performed and the test-retest volume of lipid core (sum from four slices) was reproduced to within 8.3% from post-GdDTPA T1W black blood images. In a prospective 18 month follow-up of this subject, it was found that lipid necrotic core volume was reduced by 20% consistent with the aggressive therapeutic management altering the plaque composition. In comparison at 1.5T, for the same patient it was not possible to reliably measure the lipid core volume change. Additionally, for a healthy male subject comparison of the average wall volumes obtained between 1.5T and 3.0T indicated that both reduce SNR and increased blur produceaverage wall areas that are 21% larger at 1.5T with twice the standard deviation. We conclude that 3.0T is the field strength of choice for carotid plaque characterization and prospective quantitative studies.

Acknowledgements: Funding from the American Heart Association and Pfizer supported this work.

References: 1. Yarnkyh et al., JMRI 2006;23: 691 **2**. Hinton, et al.. EJR 2006, 57:403 **3.** Yuan et al., JMRI 2002, 15:62.