DSCT and 3T MR for Characterization of Carotid Plaque in Patients

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Introduction: Atherosclerotic disease is a significant cause of morbidity and mortality. Recent studies have suggested that plaque composition is an important prognostic factor and may be more predictive of adverse outcomes than overall degree of stenosis. Previous studies have attempted to characterize carotid plaque components using various imaging modalities. In this small patient study, we looked at the relative efficacy of two new technologies, 3 Tesla (3T) MR and Dual Source CT (DSCT) to evaluate plaque components. We hypothesized that these modalities could provide improved depiction of plaque components, which may have important diagnostic and therapeutic implications.

Methods: Over a period of 3 months, 6 subjects with known carotid atherosclerotic disease were scanned on a 3.0T system (Tim Trio, Siemens, Erlangen, Germany) using a 4-channel bilateral carotid phase array surface coil. T1, T2 and Proton Density (PD) images were acquired with parallel spatial presaturation regions above and below the imaging volume to saturate inflow. In-plane spatial resolution was 0.5x0.5 mm with a slice thickness of 2mm. An interslice gap of 0.2mm was prescribed. A receiver bandwidth of 130 Hz/pixel was used with spectrally selective fat saturation. For the T1 sequence TR/TE = 863/12 with two signal averages. The echo-train length (ETL) was 7. For the Proton Density weighting TR/TE=1600/12 with an ETL of 7 with two signal averages. For T2 weighting a single signal average was acquired with TR/TE = 1600/75 and an ETL of 15. A 3D Turbo spin echo sequence (SPACE) was acquired with 56 phase encoding steps in the slice select direction giving an isotropic volume resolution of 0.7mm3.[1] The sequence used a variable refocusing flip angle evolution optimized for T2 contrast. TR/TE = 1600/161 ms. ETL 33 with slice turbo-factor 2. Scan duration 4m28s. In-plane parallel imaging (iPat - Grappa) was used with an acceleration factor of 2. The same sequence was also acquired with additional flow sensitizing gradients to improve nulling of blood signal with motion sensitizing gradient pulses with 1st order gradient moment = 554 $mTms^2/m$ in the read, phase and slice direction. Subjects also underwent carotid protocol DSCT scanning (SOMATOM Definition, Siemens, Erlangen, Germany), receiving 100 mL of Omnipaque 350 contrast, delivered at a rate of 5 mL/sec. Image optimization was achieved through bolus tracking. Images were reviewed by an experienced radiologist and were assessed quantitatively in terms of Hounsfield units and areas of calcium seen on DSCT images. An average of four levels were examined within each region of plaque and graded on a four-point qualitative scale from 0-3. Qualitative results for the MR studies were averaged and compared with CT results for areas of calcium and soft plaque.

Results: Image quality analysis score for soft plaque: MR avg = 1.75 CT avg = 1.0 results significant (Two-tailed t-test $p = 0.02$). PD avg = 2.38 results significant ($p = 0.0001$) when compared to CT. Image quality analysis score for calcified plaque: MR avg = 1.44, CT avg = 2.88, results significant ($p = 0.000002$) T1W avg = 1.75 results significant ($p = 0.001$) when compared to CT. A region of interest (ROI) was placed around all calcified plaque to measure Hounsfield units at 80kV, 140kV, and combined dual energy. The ratio of HU was 1:0.7:0.8 respectively. ROI was placed around each calcified plaque to measure area in sq cm at 80kV, 140kV, and combined dual energy. The ratio of area sq. cm were 1:0.8:0.9 respectively.

Conclusions: Qualitative data indicate that 3T MR is superior to DSCT for the assessment of regions of soft plaque in the carotid arteries. Of the four MR sequences examined, PD scored highest. In the evaluation of calcified plaque, DSCT yielded better image quality compared to all MR sequences. Of the four MR sequences examined, T1W scored highest for calcium assessment. Ratios of Hounsfield units and relative areas of calcium indicate that the 80kV energy on DSCT may be overestimating calcified portions of plaque. Less blooming artifact is apparent at higher energy (140 kV). These results indicate that 3T MR and DSCT may both be useful for characterization of carotid artery plaque *in vivo*.

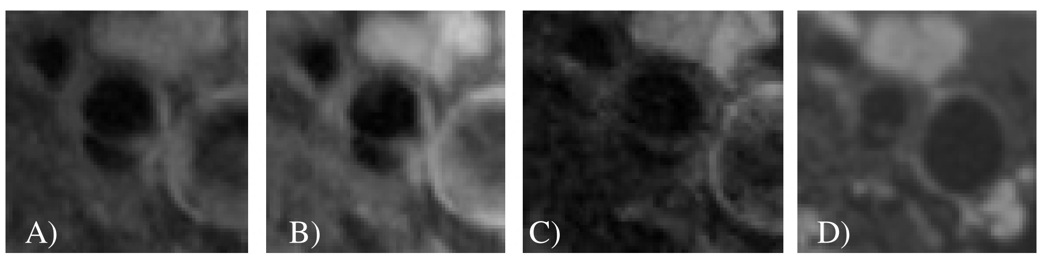

Figure 1. 3T MR Images. A) T1W B) PDW C) T2W D) 3D SPACE

References: [1] Chung et al.; Proc 14th ISMRM, p. 653, 2006

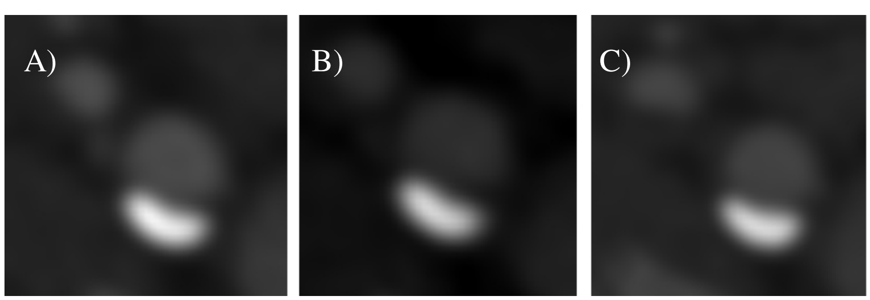

Figure 2. DSCT images. A) 80kV shows increased area of Ca and “blooming” artifact B) 140 kV shows reduced apparent area of Ca C) Combined energy has intermediate Hounsfield units and relative area