T1 Contrast of MPRAGE in Carotid Plaque Imaging

Y-C. Chung[1], M. Jerosch-Herold[2], R. T. Seethamraju[3], P. Libby[4], M. Di Carli[5], and R. Kwong[6]

[1]Siemens Medical Solutions USA, Inc., Columbus, OH, United States, [2]Radiology, Brigham and Women's Hospital, MA, United States, [3]Siemens Medical Solutions USA, Inc., MA, United States, [4]Cardiovascular Medicine, Brigham and Women's Hospital, MA, United States, [5]Nuclear Medicine, Brigham and Women's Hospital, MA, United States, [6]Cardiovascular Imaging, Brigham and Women's Hospital, MA, United States

Introduction Magnetization prepared gradient recalled echo (MPRAGE) has high diagnostic value in thrombus imaging [1]. With strong T1 weighting for tissue contrast, MPRAGE may be a good technique for plaque characterization requiring T1 contrast. For instance, MPRAGE may help depict vessel wall and lumen since blood has a longer T1 than vessel wall [2] (more so at 3.0T). In this study, we explore how the strong T1 contrast from MPRAGE at 3.0T may provide new information about the artery/lumen/plaque in an initial patient cohort with known atherosclerotic carotid artery disease.

Method The study was part of a larger carotid plaque study approved by the institutional review board. It was performed on a 3.0T clinical scanner. A custom-built 8-channel carotid coil previously described in [3] was used. 10 patients known to have carotid stenosis from ultrasound exam, and successfully went through the MR imaging examination with no motion were included in this study.

Imaging: 2D TOF images were acquired to identify the carotid bifurcations, followed by T2 weighted SPACE (or T2w-SPACE, a variant of 3DTSE) with high spatial resolution (0.7mm iso) [4, 5]. MPRAGE was then run using these parameters: TR/TE=8.3ms/3ms; water excitation pulse; flip angle=12^{o}; TI=1000ms (> blood null point at 3T); inversion pulse repeated every 1900ms; bandwidth=200Hz/pixel; voxel size=0.65mm^3 (isotropic); phase/slice resolution=100%; partial Fourier not used; 144 slices acquired in 6min.

Image Analysis: 10 studies were evaluated. The two high resolution 3D dataset were co-registered using commercial fusion software. Plaque locations were identified. The vessel lumen in the axial and longitudinal views of each vessel from T2w-SPACE and MPRAGE were compared. The contrast of various plaque components in T2w-SPACE and MPRAGE was also compared.

Results (1) In all images reviewed, Blood was well suppressed (i.e., dark) in T2w-SPACE. In MPRAGE, blood signal was grey except at tight stenoses where it was dark (Fig 1). (2) Three patients had plaques with high signal in MPRAGE but not in T2w-SPACE, suggestive of thrombus [1] (Fig 1). (3) In two cases, the blood signal in the vessel lumen in MPRAGE was attenuated over a 40mm segment at one of the carotid arteries (Fig 2), consistent with artifacts observed in TOF images, and suggestive of a carotid stent. This feature was not observed in T2w-SPACE. (4) In a case where one artery is totally occluded, the vessel lumen beyond the blockage could be identified in MPRAGE but not in T2w-SPACE (Fig 3). (5) In one carotid artery, a bright "lump" at the bifurcation in T2w-SPACE mimicked residual blood. In MPRAGE the fibrous cap of the "lump" could be depicted (Fig 4).

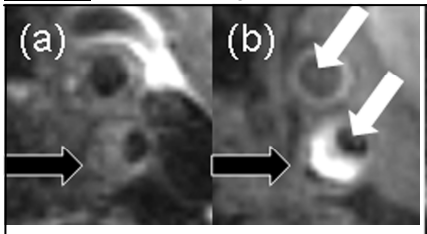

Fig 1. The thrombus's appearance (black arrows) in T2w-SPACE (a), and MPRAGE (b). At the stenosis, the blood signal is lower than that of the non-stenotic lumen in MPRAGE (b). See white arrows.

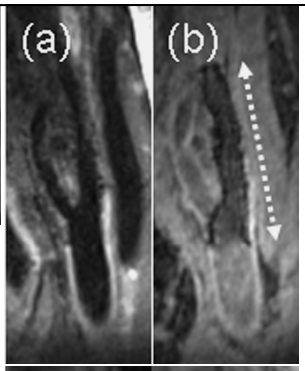

Fig 2. Appearance of a carotid stent in T2w-SPACE (a) and MPRAGE (b). Signal void from metallic artifact in T2w-SPACE cannot be depicted in dark blood images, but the signal attenuation of flowing blood is obvious in MPRAGE.

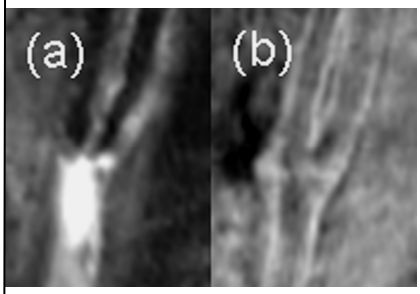

Fig 3. The blocked common carotid artery was bright in T2w-SPACE (a) but grey/dark in MPRAGE (b). The vessel wall and lumen at the common carotid artery is still visible beyond the blockage in MPRAGE.

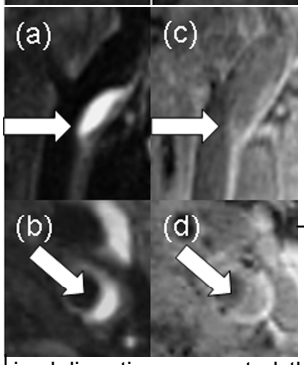

Fig 4. The plaque looked like residual blood in T2w-SPACE (a, b). In MPRAGE (c, d), the blood and the fibrous cap of the plaque was visible.

Discussion Blood appears grey in MPRAGE when TI used was longer than the blood null point. In Fig.1, the blood signal void in MPRAGE is probably due to signal dephasing related to high velocity blood flow. Fig.1 also showed that the TI used did not seem to affect the sensitivity of MPRAGE in delineating suspected thrombus. In Fig.2, the "grey" blood through the stent in MPRAGE was still visible, though attenuated due to Faraday cage effect [6]. Meanwhile, signal void from the stent in T2w-SPACE is indistinguishable from the lumen where blood is also dark. "Grey" blood in MPRAGE helped to lumen in this case. Fig.3 shows that MPRAGE can help visualize segments of vessels where blood was stagnant. In Fig.4, the good T1 contrast between blood and vessel wall helps depict the fibrous cap which was difficult to visualize in T2w-SPACE due to the bright constituent in the plaque.

Conclusion Our pilot study showed that (1) choice of TI longer than the null point of blood in MPRAGE creates a unique contrast that can help differentiate blood and vessel, hence complementing the dark blood images; (2) the "grey blood" contrast may be useful in depicting other image features (such as calcium, hemorrhage, susceptibility artifact, etc.) not prominent in dark blood images. The preliminary results suggested that MPRAGE may have a more important role in carotid plaque imaging than commonly known.

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