In Vivo High-Resolution Volumetric Imaging of Carotid Complicated Plaque: 3-Dimensional High-Resolution Magnetic Resonance Direct Thrombus Imaging (hiresMRDTI)

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Background: Intraplaque hemorrhage/thrombus (IPH/T) is increasingly being recognized as one of the markers that defines atherosclerotic plaques as being at increased risk of causing symptomatic disease, as well as being a potential stimulus for the progression of atherosclerosis (1-2). We have successfully developed MRI techniques that, by exploiting the T1 shortening effects of methemoglobin, directly visualize hemorrhage/thrombus in atherosclerotic plaque, detecting complicated plaque (AHA Type VIb/c). This technique has been termed Magnetic Resonance Direct Thrombus Imaging (MRDTI) (3). The purpose of this study was to develop a high-resolution version of MRDTI, to directly visualizing IPH/T and therefore complicated atherosclerotic plaques in the carotid arterial circulation.

Methods: Fifteen patients (13 male, 2 female, mean age 71 ± 6.1 years [59-80 years]) undergoing carotid endarterectomy for symptomatic or asymptomatic carotid artery stenosis were imaged at 1.5T (GE Twin Speed MR scanner, USA) using high-resolution Magnetic Resonance Direct Thrombus Imaging (hiresMRDTI) and a dedicated carotid surface coil (SCANMED, USA). The scanning parameters were: TR 11.2ms, TE 3.3ms, flip angle 15°, FOV 80mm^2, matrix 160^2, slice thickness 1mm, spatial resolution 0.5mm x 0.5mm x 0.5mm (IP). Fat suppression was achieved using *SPECIAL* (*SPEC*tral *I*nversion *A*t *L*ipids), a GE proprietary technique. hiresMRDTI involved multiphasic acquisitions, and images were registered to each other as previously described (4). A total of 160 axial MRI images were acquired for each patient, and were available for matching with the corresponding histology slices. Endarterectomy specimens were fixed, decalcified, sectioned and stained with Hematoxylin & Eosin. Matching of MRI and histology slices employed the distance from the bifurcation, and vessel/plaque morphology. A 16-segment template was used for MRI/histology correlation. Agreement between MRI and histology was measured by calculating Cohen's kappa.

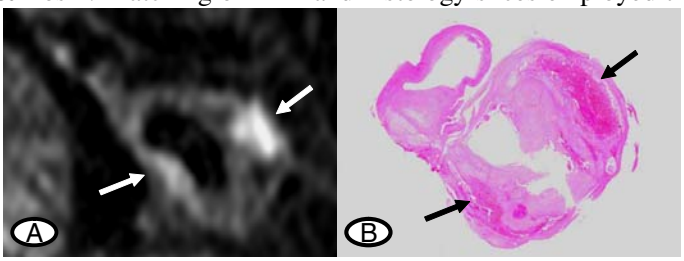

Figure 1. Magnetic Resonance Direct Thrombus Imaging in a 74 year-old male with asymptomatic carotid stenosis. (a) High-resolution MRDTI (hiresMRDTI) at the level of the bifurcation. Note how the vessel wall, the carotid bifurcation and the location of the intraplaque hemorrhage (high signal, arrows) are clearly demonstrated. (b) Corresponding Hematoxylin & Eosin-stained section of carotid endarterectomy specimen at the level of the carotid bifurcation confirms the presence of intraplaque hemorrhage (arrows).

Results: A total of 455 segments were matched between hiresMRDTI and histology. Good-to-very good agreement was seen (kappa=0.7) (Fig. 1). The sensitivity / specificity / positive predictive value / negative predictive value were: 73% / 93% / 85% / 87%.

Conclusion: hiresMRDTI allows very good delineation of the exact location of intraplaque hemorrhage/ thrombosis in the plaque, resulting in good-to-very good agreement between imaging and histology. Being a 3D technique, hiresMRDTI allows multiplanar reformations (Fig. 2), as well as providing a large number of images for analysis. These features of hiresMRDTI could be useful to gain a better understanding of plaque pathophysiology, and to monitor the effects of therapy on atherosclerotic plaques.

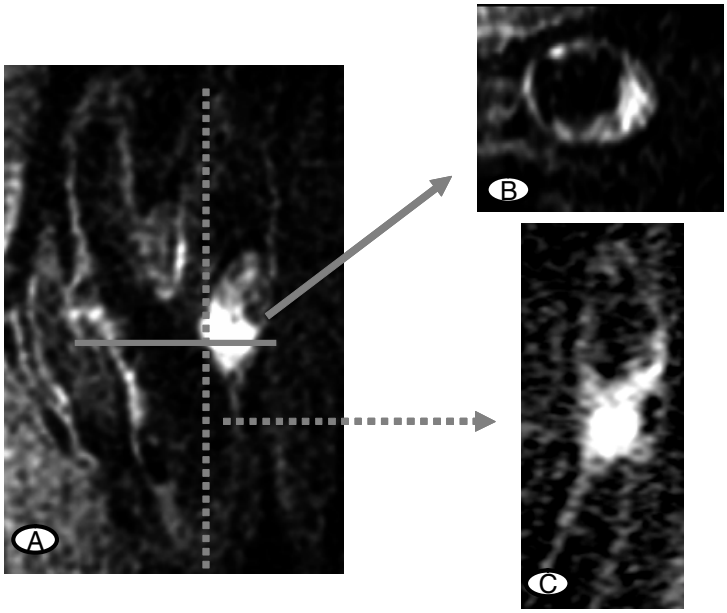

Figure 2. Multiplanar reformats of hiresMRDTI. FOV 80mm^2, matrix 160^2, voxel size 0.5mm^3 (a) As hiresMRDTI is a 3D volume usually acquired in the sagittal plane, axial and coronal reformats are possible. (b) Axial reformat at the level of the solid gray line. (c) Coronal reformat at the level of the hatched gray line.

References:

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