MPRAGE detection of hemorrhage in carotid plaque

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INTRODUCTION: Plaque hemorrhage is thought to discriminate an unstable plaque from a more stable lesion (1-6). Recent advances in MR imaging have found that heavily T1 weighted inversion recovery sequences aid in the identification of plaque hemorrhage (7-8). High signal on these sequences is associated with recent ipsilateral ischemic events (9). Prior studies have demonstrated that both hemorrhage and lipid-rich necrotic cores display signal hyperintensity on conventional T1 weighted imaging. It is important to discern between plaque components such as lipid, necrotic core, and hemorrhage, since they may have different effects on plaque stability and the risk of neurologic events. Further, their definite identification will allow for assessing the natural history of changes in plaque composition and their response to medication.

METHODS: Patients scheduled for carotid endarterectomy (CEA) underwent imaging using a Siemens Trio 3T MRI scanner, a custom made 4-element phased array coil and the following sequences: 3D MPRAGE (Magnetization-prepared rapid acquisition with gradient-echo, 0.5 X 0.5 x 1 mm^3), 3D TOF (Time of Flight, 0.3 x 0.6 x 0.6 mm^3), 2D DIR T1 and T2 images (0.5 x 0.5 x 2 mm^3). After CEA, specimens were fixed in 10% buffered formalin, decalcified, and serially sectioned. Specimens were stained using both Hematoxylin/Eosin and Trichrome staining. MR images and histological slides were matched and plaque components identified.

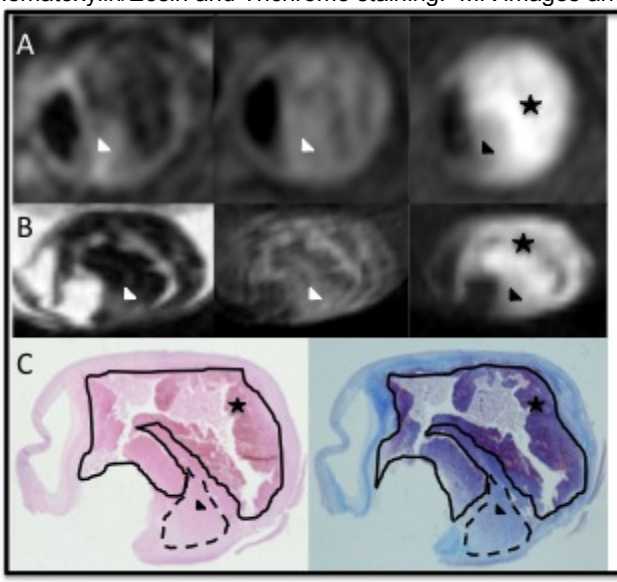

Figure 1: (A) Left to right: T2, T1 and MPRAGE MR images of a right internal carotid artery specimen prior to CEA. (B) Left to right: Ex vivo T2, T1 and MPRAGE MR images of the CEA specimen. (C) Left (Hematoxylin/Eosin) and Right (Trichrome) histology specimens outlining plaque components. Key: Hemorrhage (stars, continuous outline), necrosis (arrowheads, dotted outline).

Figure 2: Histology of MPRAGE positive plaques demonstrating degenerated red blood cells with admixed intact red blood cells (Left, Trichrome), degenerated red blood cells and cholesterol clefts (Middle, Hematoxylin/Eosin) and hemosiderin laden macrophages (Right, Hematoxylin/Eosin).

RESULTS: MPRAGE hyperintensity correlates with hemorrhage on histology (Figure 1). Variable ages of blood products were detected by the MPRAGE sequence, ranging from recent to remote (Figure 2). Lipid and necrosis, which also shorten T1, can be discriminated by a lower signal on the MPRAGE sequence (Figure 1). Other components, including collagen rich tissue and calcium, are dark on MPRAGE.

DISCUSSION: Discrimination of hemorrhage from lipid, necrosis, collagen, and calcification can be made with the MPRAGE sequence. The MPRAGE sequence detects blood products of a variety of ages, and may quantify the risk of future events. Further, it may play an important role in determining which patients benefit from medical management as opposed to surgical intervention.

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