Fibrous Cap and Lipid Rich Necrotic Core are Difficult to be Distinguished with Routine Image Weighting at 3T

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Introduction: Multi-contrast vessel wall imaging sequences have shown the ability to distinguish various components in carotid plaque by measuring weightings of basic MR constants. In other words, the discrimination capability of MRI mainly depends on the differential of basic MR constants of different components. Previous studies were mainly focused on the image properties to detect different tissue. For example loose matrix represents hypo intensity in T1 weighted image and hyper intensity in T2 weighted image, while calcification shows hypo intensity in T1, T2 and Pd weighted images [1]. In our study, 4 types of tissue in the plaque were compared quantitatively to find out whether they can be distinguished by routine MR sequences on a clinical 3T system.

Methods: Eight carotid endarterectomy specimens were imaged on a 3T MR scanner (Phillips Achieva). T1 mapping was measured by saturation recovery spin echo sequences (SRSE) with various delay times and a nonlinear fitting algorithm. T2 mapping and T2* mapping were acquired by SE and GRE sequences with different TEs and least square linear fitting algorithm after logarithmic simplification. An experienced reviewer outlined fibrous tissue, loose matrix, lipid rich necrotic core (LRNC), and intra-plaque hemorrhage (IPH) regions respectively on MR images guided by matched histology. Averages and standard deviations of mean values in these regions were calculated for different components. The significance of difference was shown with the distribution of MR constants.

Results and Discussion: Figure 1 shows the mapping process. MR images (a), (b) and (c) were acquired by SRSE, SE and GRE sequences with different TD or TE values respectively. Images (d), (e) and (f) are T1 map, T2 map and T2* map after fitting. Three MR constants maps were combined into a RGB image shown in (g), in which color red, green and blue represent T1, T2 and T2* respectively. The matched histology section is shown in (h). Contours used to calculate the quantitative information are illustrated in (i), and the results are listed in table 2. The distribution of MR constants was plotted in figure 2 assuming Gaussian distribution. IPH produces shortest T1, T2 and T2* in all types of tissue, while loose matrix had the longest relaxation time. The standard deviation of LRNC at T1 is large because of the mixture of cholesterol clefts (decreased signal) and cellular debris (increased signal). T2* of LRNC is shorter than that of fibrous cap which is converse to other MR constants again probably due to the T2* decrease at the mixture of clefts and debris. The distribution of LRNC overlaps with fibrous cap for all MR constants, so it is difficult to tell them apart with T1, T2, and T2* weighted images. Other properties of fibrous cap and LRNC such as different permeability should be used with contrast agent injection also suggested by other researchers [2]. This study provides quantitative information for different plaque components, which can highlight the possible direction for sequence design to detect specific components.

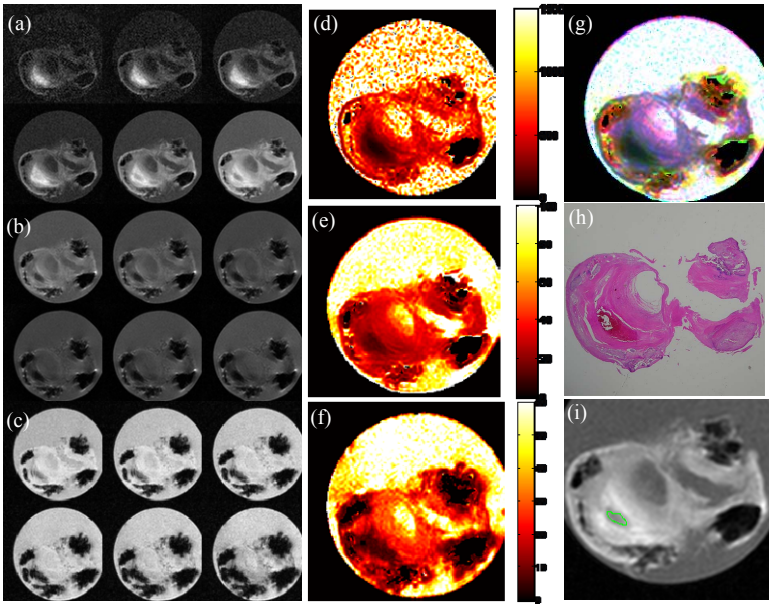

Figure 1. Quantitative mapping process (a) Saturation recovery images for T1 mapping; (b) Multi TE spin echo images for T2 mapping; (c) Multi TE gradient echo images for T2* mapping; (d) T1 map; (e) T2 map; (f) T2* map; (g) Combined RGB map; (h) Corresponding histology; (i) Contours drawn by an experienced reviewer.

Table 2. Average MR constants of different plaque components

Plaque components	T1 (ms)	T2(ms)	T2*(ms)
Fibrous Tissue (n=14)	558.59±116.89	29.88±3.57	25.70±4.28
Loose Matrix (n=13)	1074.74±191.65	42.78±4.94	28.70±5.60
LRNC (n=21)	815.77±278.21	34.25±4.26	18.67±2.37
IPH (n=2)	123.62±71.52	15.65±4.23	8.37±3.06

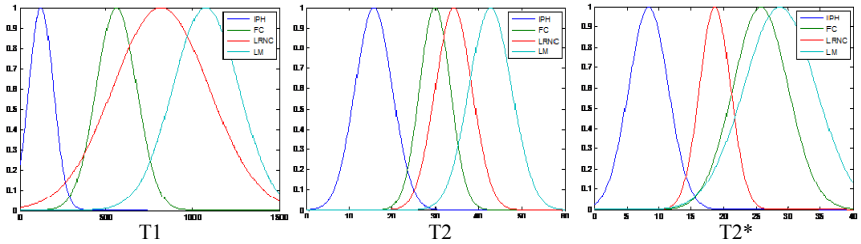

Figure 2. MR Constants Distribution

Reference: [1] Samm T, et al. ATVB. 2005; 25(1):234-239.

[2] Yuan C, et al. JMRI. 2002; 15(1):62-67.