Signal Features of the Atherosclerotic Plaque at 3.0T versus 1.5T: Impact on Automatic Classification

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Introduction

Several automatic classifiers have been proposed for analyzing carotid atherosclerotic plaque imaged with multiple-contrast-weighted vessel wall MRI [1-3]. These classifiers have been trained using data from individual scanning platforms, which may limit their applicability at other sites. Furthermore, 3T vessel wall imaging [4,5] leads to alterations in MR parameters, which may alter image contrast, further eroding classifier performance. The purpose of this investigation was to compare performance of a classifier trained on 1.5T data in subjects scanned both on the same 1.5T scanner and on a 3T scanner.

Methods

Twenty asymptomatic subjects with 16-79% carotid stenosis were imaged with closely matched protocols on 1.5T (GE Signa) and 3T (Philips Achieva) MRI scanners. Axial images at 2mm intervals were obtained with T1 (TR = 800/800 [1.5T/3T]; TE = 11/9), T2 (TR = 3000/4000; TE = 54/52), proton density (PD; TR = 3000/4000; TE = 9/8), 3D time-of-flight (TOF; TR = 23/20; TE = 4/5), and contrast-enhanced (CE) T1 weightings. Image locations were matched across contrast weightings and field strengths using the carotid bifurcation as a landmark. Matched locations were then analyzed by interactively drawing lumen and wall contours and registering all contrast weightings. Finally, the morphology enhanced probabilistic plaque segmentation (MEPPS) algorithm [1] was applied to segment the vessel wall into fibrous tissue, calcification, lipid core, and hemorrhage components. To validate the performance of MEPPS, which had previously been trained using in vivo 1.5T MRI and matched histology from 25 endarterectomy subjects, regions were also identified by manual drawing on the 1.5T images using established manual review criteria [6].

Results

A total of 218 matched locations were available. An example showing matched contrast weightings at both field strengths is shown in Figure 1. Comparisons of classification results are shown in Table 1. The average areas per slice of calcification and lipid core were underestimated by MEPPS compared with manual review leading to significant overestimation of fibrous regions (comparison by paired t-test). Nevertheless, Pearson correlation (R) between methods was high (near 0.9) indicating strong interdependence of measurements. Agreement between methods on the presence or absence of components in a slice was also very good (Cohen's κ near 0.7). Measurements of average areas showed no significant differences comparing 1.5T and 3T results, although calcification showed a trend (P=0.09) for larger measurements at 3T. The measurements at 3T and 1.5T also exhibited strong correlations (R>0.9) and very good agreement (Cohen's κ near 0.7). Visual assessment of plaque distributions (Figure 2) showed excellent agreement in the size, shape, and location of segmented regions.

Conclusions

This analysis shows that a classifier trained at 1.5T can exhibit largely equivalent performance on a 3T platform, suggesting signal properties are sufficiently similar at 3T. Key aspects of the MEPPS algorithm that contribute to this conclusion are its incorporation of intensity normalization and coil correction algorithms and its use of vessel morphology to improve segmentation performance. A likely disparity between 1.5T and 3T was observed for calcification, which is expected given the larger susceptibility effects of calcification at higher fields. For optimal performance, the classifier should be trained on the specific platform, but this result suggests that this classifier can have nearly optimal performance across a range of platforms.

References

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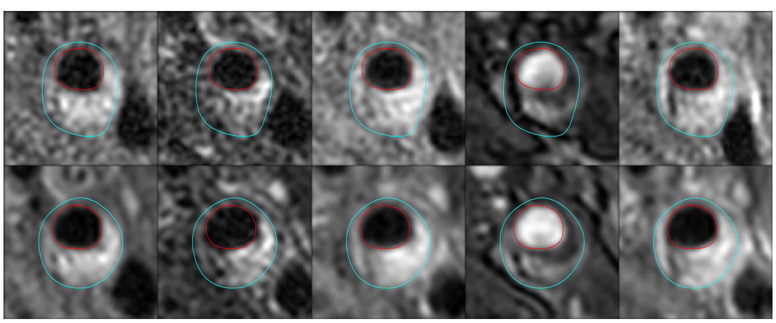

Figure 1. Comparison of 1.5T (top) and 3T (bottom) imaging results showing (left to right) T1, T2, PD, TOF, and CE-T1 weightings

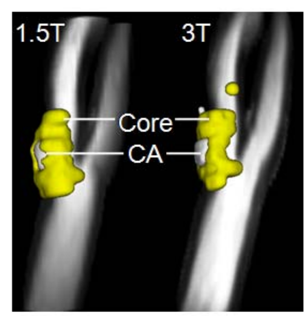

Figure 2. 3D renderings of regions and TOF MRA via MRI-PlaqueView (VPDiagnostics, Seattle, WA)

Table 1. Comparison of average areas per slice and agreement on presence /absence of components

	1.5T MEPPS	1.5T manual*	1.5T: manual vs. MEPPS		3T MEPPS*	MEPPS: 1.5T vs 3T	
Tissue type	Area (mm^2)	Area (mm^2)	R	κ	Area (mm^2)	R	κ
Calcification	0.95	1.72 (P=0.03)	0.89	0.74	1.30 (P=0.09)	0.95	0.77
Lipid Core	1.61	2.57 (P=0.07)	0.88	0.68	2.17 (P=0.3)	0.91	0.68
Hemorrhage	1.26	1.30 (P=0.9)	0.92	0.61	1.23 (P=0.8)	0.93	0.65
Fibrous	31.91	30.15 (P<0.001)	0.94	-	31.39 (P=0.3)	0.93	-

*P values by paired t-test comparing to 1.5T MEPPS; - fibrous tissue present in all slices, precluding computation of κ