Reproducibility Assessment of Morphology-Enhanced Probabilistic Plaque Segmentation (MEPPS) on Two Baseline Magnetic Resonance Scans

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Introduction:

Non-invasive high-resolution magnetic resonance imaging (MRI) has high potential for characterizing atherosclerotic plaque components by combining information from multiple MRI contrast weightings [1]. In a previous study [2], MEPPS was introduced as a promising algorithm for automatic *in vivo* plaque component analysis. Correlations between area measurements by MEPPS and subsequent histological measurements of plaque components yielded correlations of 0.88 for necrotic core, 0.91 for calcification, and 0.64 for loose matrix. This study evaluates the *in vivo* reproducibility of plaque segmentation by MEPPS.

Purpose:

Test the inter-scan reproducibility of MEPPS for segmentation of 3 types of carotid atherosclerotic plaque components: calcification, necrotic core, and loose matrix.

Methods:

As part of the 2-year ORION (Outcome of Rosuvastatin treatment on carotid artery atheroma: a magnetic resonance Imaging ObservatioN) trial with rosuvastatin [3], a total of 43 subjects (30 men, 13 women; mean age 65 years), with 16%–79% carotid stenosis, were imaged by serial MRI including two baseline exams. The baseline exams were separated by no more than 2 weeks. A standardized protocol was used to obtain axial images with four contrast-weightings: T1-weighted (T1W), proton-density-weighted (PDW), T2-weighted (T2W), and 3-dimensional time-of-flight (3D-TOF) MR angiography. A total of 58 carotid arteries were found to have overlapping coverage centered on the bifurcation and interpretable image quality for both baseline exams. The lumen and outer wall contours were drawn manually by trained radiologists on one contrast weighting. Images from the remaining contrast weightings were aligned with these contours with the aid of an automated registration algorithm [4]. Both manual segmentation by the radiologists and automated segmentation by MEPPS were performed and the total volumes of each component were recorded.

Results:

A segmentation example is shown in Fig. 1. Bland-Altman plots for the three types of tissue for both manual and MEPPS segmentation are shown in Fig 2. Quantitative statistical results are shown in Table 1. For calcification, the intra-class correlation coefficient (ICC) for MEPPS was slightly better than for manual histological review. On the other hand, manual histological segmentation showed slightly higher consistency for necrotic core and loose matrix. In comparing MEPPS and manual histological results directly, calcification showed very high correlation, necrotic core showed good agreement, but there was poor agreement for loose matrix. These results may be due to 3 reasons. First, calcification is well defined as a uniformly dark region, which makes its detection reliable. Second, although necrotic core exhibits variable signal properties, it occupies relatively large areas in the plaque, which makes its quantification relatively accurate. Loose matrix generally occurs in small regions, close to lumen where MR images suffer from flow artifacts, and is best identified on contrast-enhanced images, which were not included in this study.

Conclusion:

Both the visual and quantitative comparison between manual histological drawing and MEPPS for *in vivo* plaque segmentation demonstrates that MEPPS and manual histological drawing achieve comparable reproducibility. Thus, MEPPS can be used in therapeutic clinical trials and in prospective longitudinal studies to examine carotid atherosclerotic plaque progression and regression to reduce radiologists' work in large studies.

References

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2. Liu F, et al. *MRM* submitted 2005
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4. Kerwin W, et al. *SPIE* 2001.

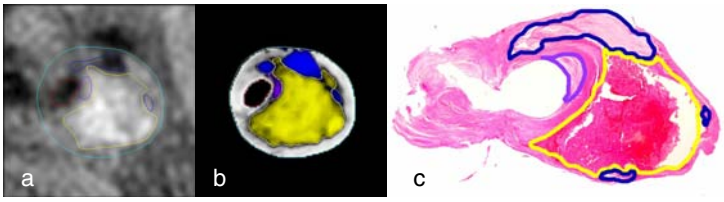

Fig 1. Segmentation example. (a) manual segmentation on T1 image (b) MEPPS segmentation on probability map (c) histological segmentation

Table 1. Statistical results of manual and MEPPS segmentation on the two baseline scans

Tissue	ICC – manual	ICC-MEPPS	R (MEPPS vs. Man)
Core	0.95	0.90	0.77
Calc	0.94	0.97	0.93
Matrix	0.82	0.80	0.27

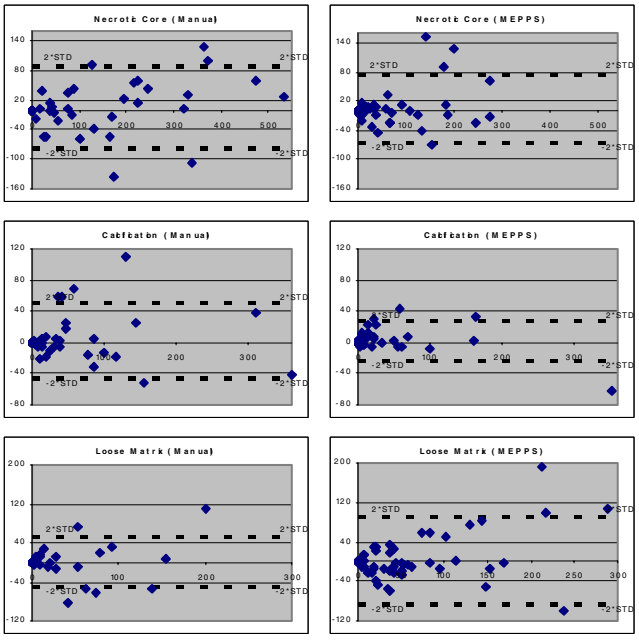

Fig 2. Bland-Altman plot of tissue volume in mm^3 from manual and MEPPS segmentation for two baselines. x axis indicates (2nd_scan+1st_scan)/2, y axis indicates (2nd_scan-1st_scan).