Assessment of an automated vein segmentation algorithm for MRI brain acquisitions at different field strengths

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Background: Several automated or semi-automated schemes have been proposed for intracranial vein segmentation (IVS) from MRI datasets. However, mainly due to the high variability of the susceptibility weighting of the contrasts at different strengths of the magnetic field (Bo), the assessment of IVS algorithms is usually performed at a fixed Bo value[1-3].

Objectives: To assess the performance of our fully automated multi-parametric IVS algorithm[4-5] (MAVERIC), originally intended and validated for 3 T MRI datasets, at different field strengths.

Methods: 3D double-echo spoiled gradient echo (GRE) sequences with flip angle close to the parenchyma Ernst angle were acquired at 1.5, 3 and 7 T in 4 volunteers. The voxel size and repetition- (TR) and echo- (TEs) times were chosen to provide similar susceptibility weightings at the different Bo in a clinically acceptable acquisition time:

- Bo=1.5 T: Resolution=$0.7 \times 0.7 \times 1$ mm^3; TR=36 ms; TE$_{1-2}$=[13.8;27.6] ms;
- Bo=3 T: Resolution=$0.5 \times 0.5 \times 1$ mm^3; TR=31 ms; TE$_{1-2}$=[7.38;22.14] ms;
- Bo=7 T: Resolution=$0.5 \times 0.5 \times 0.5$ mm^3; TR=25 ms; TE$_{1-2}$=[6.12;17.33] ms.

For each dataset, IVS maps were derived by the MAVERIC segmentation tool and 2 experienced neuroradiologists were asked to grade on a 0-5 scale (0 corresponding to the lowest reliability of the voxel classification; 5 reflecting an optimal compromise between sensitivity and specificity) the accuracy of 4 segmentation MIPped slabs (thickness of 20 mm) compared to the corresponding SWI mIPs.

Results: Illustrative segmentation results obtained at 1.5, 3 and 7 T are shown in Fig. 1, 2 and 3, respectively, where the obtained voxel classifications are placed side by side with the corresponding SWI and their fusion. The accuracy scores at 1.5, 3 and 7 T were 4.19 ± 0.66; 4.44 ± 0.51; 4.56 ± 0.51, respectively. Scores obtained at 1.5 and 7 T were not significantly different from scores already assessed at 3T[4] ($p=0.29$ and $p=0.50$, respectively, at Mann-Whitney U-tests).

Conclusion: At all considered field strengths, MAVERIC provided comparably accurate IVS, given that visible vessel density increases with Bo.

Fig. 1. Segmentation result at 1.5 T. From left to right: MAVERIC-MIP; fusion of SWI-mIP with MAVERIC-MIP; SWI-mIP. Image projections cover 20 mm in the head-foot direction.