New perspectives for vascular dementia patients at 7T!

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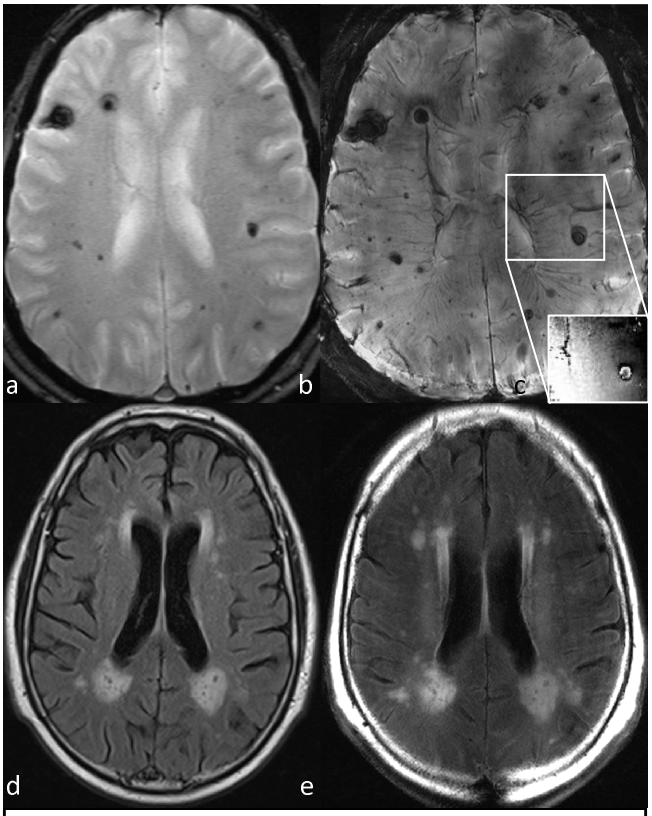
Introduction: Sophistication of cerebral imaging has deepened our understanding of cerebrovascular changes. In the beginning, computed tomography (CT) was able to confirm lacunar infarcts, areas of white matter disease (leukoaraiosis), larger matter defects, or calcifications in the white matter. During the last 25 years, the quality of MRI scans has improved enormously. MRI turned out to be valuable using fluid-attenuation-inversion-recovery sequences (FLAIR) for depiction of the extent of the white matter disease (characteristic of small vessel disease), and was later also able to identify small cortical lesions that were not identified on "older" sequences. Furthermore, developments in gradient-echo sequences yielded better T2*-weighted imaging and more recently susceptibility-weighted-imaging (SWI) for the improved detection of deoxyhemoglobin (as seen in microbleeds or cavernomas) and calcifications. The introduction of high field magnetic resonance (MR) imaging systems (7 Tesla) for human imaging is another important development which might provide potential for further improving this diagnostic technique. For optimal results, the adaptation of established (1.5 or 3 Tesla) clinical sequences is required. Higher field strengths provide superior tissue signal and enhanced sensitivity to susceptibility differences, so it seems reasonable that 7T should offer potential for enhanced high-resolution depiction of white matter changes and the detection of blood products or calcifications.

The purpose of this study was to evaluate the value of 7 Tesla MRI in the assessment of cerebrovascular alterations as seen in vascular dementia (VD) by means of depiction of white matter changes and the detection of microbleeds; extent and localization of white matter changes might be helpful in determining the nature of these alterations (VD vs. mixed dementia), whereas microbleeds might be indicative of higher future risk for intracerebral hemorrhage.

Methods: All measurements were performed on a whole-body 7 Tesla scanner (Magnetom 7T, Siemens Medical Solutions, Erlangen, Germany). Previously optimized FLAIR, T2*, and SWI (3D) sequences were used in eight patients with known microangiopathy and/or microbleeds. For signal transmission and reception, an eight-channel head coil was employed (Rapid Biomedical, Wurzburg, Germany). This multi-channel coil allowed parallel imaging (GRAPPA, R=2). Comparison images at 1.5T were acquired using a standard clinical scanner (Avanto, Siemens Medical Solutions, Erlangen, Germany) with a 12-channel receive array as provided by the manufacturer. 7T images were compared to 1.5 Tesla images by two neuroradiologists.



Patient I: T2* at 1.5T (a) and 7T (b), SWI phase information insert (c) - multiple cavernomas.
Patient II: FLAIR at 1.5T (d) and 7T (e) – extensive microangiopathy.

Results and discussion: The depiction of the pathology with respect to surrounding brain tissue was achieved in all eight subjects. Imaging time ranged from 2:31 min. (T2*, GRAPPA R=2) to 7:21 min (SWI: 0.32x0.32x1.7mm^3; GRAPPA=2) per acquisition and allowed coverage of the whole head in 45 minutes. The 2D sequences (FLAIR, T2*) were limited by SAR, requiring usage of multiple slice packages to cover the region of interest seamlessly (2 packages for T2*, 6 for FLAIR). One strategy was to use gap filling (gap=100%) and cover the region of interest with two concatenations. T2* (flip angle=60°, TR=600 ms, TE=15 ms, FOV=173x230 mm^2, matrix=768x1024 int., voxel=0.22x0.22x3 mm^3) and SWI (flip angle=15°, TR=26 ms, TE=10 ms, FOV=163x224 mm^2, matrix=512x704, voxel=0.32x0.32x1.7 mm^3) revealed all microbleeds and cavernomas known from 1.5 Tesla. In 6/8 patients, T2* imaging showed more susceptibility "dots" compared to 1.5T (Fig. a,b); SWI improved detection in 2/8 patients. SWI phase images allowed for differentiation between small calcifications (e.g. choroid plexus) and hemosiderin deposits [1] (Fig. c). FLAIR (FOV=230x230 mm², matrix=384x384, voxel=0.3x0.3x6 mm³) images reliably highlighted white matter lesions known from 1.5T (Fig. d,e). Supratentorial disturbances produced by susceptibility artifacts and RF field inhomogeneities were acceptable; degradation was stronger close to the skull base, especially in gradient echo sequences (T2*, SWI).

Conclusion: Improved detection of microbleeds coupled with good visualization of the white matter lesion plaque burden at 7T might have significant impact on the early detection, diagnosis, and therapy of cerebrovascular patients (e.g. in VD) in the future. SWI and T2* may provide additional criteria to optimize antithrombotic treatment. New sequences and multi-channel coils will be important for optimal utilization of the advantages of ultra high-field MRI.

[1] A. Deistung, et al., Z Med Phys 16 (2006) 261-267.