

Depiction of vessel pathology in stroke imaging at 7.0T using non-contrast MPRAGE

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Target audience: Clinical (neuro)radiology and ultrahigh-field MRI

Introduction: It has been suggested that magnetization prepared rapid gradient echo (MPRAGE) imaging at 7 Tesla (7T) can be used to derive MR-angiographies (MRA) of the intracranial vasculature [1]. This is of high interest, as time-of-flight-(TOF)-imaging at 7T is strongly limited by SAR-constraints leading to small coverage and clinically unacceptable scan times [2]. To be of clinical value, MPRAGE-MRA has to meet the diagnostic level of the highest available clinical standard of non-contrast MRA, e.g. TOF-MRA at 3T. Therefore, we investigated the feasibility of MPRAGE-MRA at 7T in patients with cerebrovascular disease (stroke and Moya-Moya-disease) versus TOF-MRA at 3T.

Methods: In an ongoing, WHO-registered and prospective imaging trial, 16 patients suffering from cerebrovascular disease (n=13 stroke, n=3 Moya-Moya disease) were investigated at 7T (Magnetom 7T, Siemens Healthcare, Erlangen, Germany) using a 1/24-channel Tx/Rx coil (NovaMedical, Wakefield, MA, USA) and at 3T (Verio) using a 12-channel Rx head coil (both Siemens Healthcare, Erlangen, Germany). All patients gave written informed consent prior to the study. 7T 3D-MPRAGE parameters were: TR=2750 ms, TE=1.81 ms, acceleration factor: 3, BW: 350 Hz/Px, voxel size: (0.7x0.7x0.7) mm³, matrix size: 384x384, flip angle: 10°, acquisition time: 6:40 min. 3T 3D-TOF parameters were: TR=24 ms, TE=3.6 ms, acceleration factor: 2, BW: 186 Hz/Px, voxel size: (0.6x0.6x0.6) mm³, matrix size: 384x364, flip angle: 18°, acquisition time: 5:54 min. Image postprocessing was performed using MevisLab (Fraunhofer MEVIS & MEVIS Medical Solutions, Bremen, Germany). For 7T images, a non-uniformity correction was performed to account for transmission field induced image inhomogeneities. Intracranial MRAs were compared slice per slice (2D) using a standardized evaluation modified from [1]. Rating was performed in a consensus rating by two readers. Overall quality was rated from 1-5 (5=excellent, 4=good, 3=moderate, 2=poor, 1=non-diagnostic); additionally, the same 5-point score was applied to the following arterial segments for each MRA: 1) intracranial internal carotid artery (ICA), 2) anterior cerebral artery (ACA) A1 and A2, 3) anterior communicating artery (AcoA), middle cerebral artery (MCA) M1-M3, posterior communicating artery (PcoA), posterior cerebral artery (PCA) P1 and P2, basilar artery. Vessel pathologies were noted for each MRA-scan and compared between 7T and 3T scans. Results of the qualitative assessments were compared by Wilcoxon signed rank test. Overview 3D-angiographies (s. fig 1C) were enhanced using a vesselness filter (lower/upper sigma: 0.5mm/1.5mm, number of scales: 4).

Results: In the statistical rating analysis, no significant differences were found in the overall image quality between MPRAGE-MRA at 7T and TOF-MRA at 3T. Additionally, in none of the analyzed arterial segments significant differences between 7T MPRAGE and 3T TOF MRA quality were detected. Vessel occlusion/stenosis was identified in five patients using 3T TOF. Each individual vessel pathology was also identified using 7T MPRAGE-MRA (see also fig. 1 A). In two patients, additional pathologies were noted exclusively at 7T MPRAGE-MRA imaging.

Discussion: While 7T TOF-MRA offers unprecedented resolution for the imaging of brain vessels, its routine clinical use is highly limited owing to very long scan times and limited brain coverage. In the present work, we demonstrated that MPRAGE-MRA at 7T presents a promising alternative. Our results suggest that the diagnostic quality of 7T MPRAGE-MRA is competitive with the highest available current clinical MRA standard at 3T. In addition, however, 7T MPRAGE provides simultaneous high-resolution depiction of brain and lesion anatomy [2] within one sequence, reducing scan times significantly at 7T. Unlike TOF-MRA, MPRAGE-MRA also offers whole-brain coverage when using routine clinical scanning times. When benchmarked against 3T TOF-MRA, more vessel-pathologies were detected with 7T MPRAGE imaging. The diagnostic relevance of this finding must be validated by comparison with the gold-standard digital subtraction angiography (DSA).

Conclusion: Our pilot-study suggests that 7T MPRAGE-MRA offers diagnostic imaging quality comparable to the highest available current clinical MRI standard at 3T. The MPRAGE MRA approach is expected to provide a significant shortening of cerebrovascular scanning protocols at 7T, since it affords simultaneous anatomic and vascular imaging.

Figure 1: A and B: 24 year old patient with a left hemispheric stroke (lesion indicated by asterisk) showing an irregular stenosis of the left M1 segment (yellow arrow) in both 3T TOF (A) and 7T MPRAGE (B). 3D-maximum intensity projection of a 7T MPRAGE-MRA (C) demonstrating that whole brain coverage can be achieved within clinically acceptable scan times (6:40 min).

References:

1. Umutlu L, et al. (2013) Academic Radiology, 20(5)628-34
2. Madai VI, et al. (2012) PLoS ONE,7(5):e37631

