

Ultra-high field MRI at 7.0 Tesla in patients with ischemic or hemorrhagic stroke: a preliminary study

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Introduction

The increased SNR of 7.0 Tesla may provide additional pathophysiological information in stroke patients compared to 1.5 and 3.0 Tesla. Ultra-high field MR in stroke patients may especially increase the detection of microbleeds (due to the increased susceptibility effects) and blood products present in a fresh or older thrombus. In this preliminary study, we performed 7.0 Tesla MRI on patients for protocol optimization and report the results with comparison with lower field strength examinations in a series of 7 stroke patients with clinically and standard imaging-based proven ischemic or hemorrhagic stroke.

Methods

Imaging was performed on a 7 Tesla whole body system (Philips Healthcare) equipped with a volume transmit and 16 channel receive head coil (Nova Medical Systems). The following sequences were developed and optimized: a magnetization prepared (MP) 3D FLAIR¹ with FOV 250x250x179 mm³, acquired voxel size 0.80 x 0.82 x 0.80 mm³, TR 8000 ms, TI 2440 ms, TE 247 ms, and MP duration 100 ms; a combined time-of-flight inflow and SWI (multi-echo fast field echo, meFFE) with FOV 180x180x110 mm³, acquired voxel size 0.40 x 0.50 x 0.60 mm³, TR 22 ms, 3 echoes, TE1/TE2/TE3 2.5/9.8/17.1 ms; a T₁ 3D TFE with FOV 240x192x120 mm³, acquired voxel size 1.00 x 0.99 x 1.00 mm³, TR 8 ms, TE 3 ms; and a DTI with a FOV 220x198x100 mm³, acquired voxel size 1.49 x 1.51 x 1.50mm³, TR 6959 ms, TE 70 ms, with 6 directions, and 2 b-values b = 0 and b = 1000 s/mm². Total scan duration was approximately 30 minutes. Results of the different sequences were evaluated regarding apparent ischemic or hemorrhagic lesions. Appearances of these lesions were compared between different sequences.

Results

In total 7 patients with standard imaging-based confirmed ischemic (n=5) or hemorrhagic (n=2) stroke were scanned. In ischemic stroke patients, the ischemic area was readily visualized on FLAIR, T₁-weighted images and DTI. Based on information from the 7.0 Tesla scans, two patients were diagnosed with ischemia not previously seen on CT. Large hemorrhagic lesions were visualized comparable to the conventional MRI scans on 1.5 Tesla. In one hemorrhagic stroke patient the 7.0 Tesla scans gave additional diagnostic information regarding underlying pathology: because of the absence of a substantial amount of diffuse microbleeds the diagnosis of amyloid angiopathy was judged less likely. Microbleeds and microinfarcts were found in other patients on T₂* weighted images, especially the second echo images, that were not found on conventional MRI. Also, occluding thrombus could easily be identified in one patient due to the large susceptibility effect inherent of 7.0 Tesla MRI (*Figure*). Patients tolerated the scanning session well, with little artifacts due to movement of the patient.

Conclusion

High-field MRI with 7.0 Tesla can be performed in patients with ischemic or hemorrhagic stroke with good tolerance and little artifacts due to movement. Results of the 7.0 Tesla FLAIR, T₁ and DTI sequences were comparable to the results of similar 1.5 Tesla sequences, but with better resolution and, in 3 out of the 7 patients, additional information regarding underlying pathology compared to CT or 1.5 Tesla MRI. meFFE with 3 echoes was valuable in the identification of microbleeds, microinfarcts and thrombus. Further research regarding the additional value of 7.0 Tesla compared to 1.5 and 3.0 Tesla in stroke will be able to define the role of 7.0 Tesla in stroke imaging. For future developments the MR scan times of the 7.0 Tesla sequences have to be reduced to increase the feasibility in patient studies.

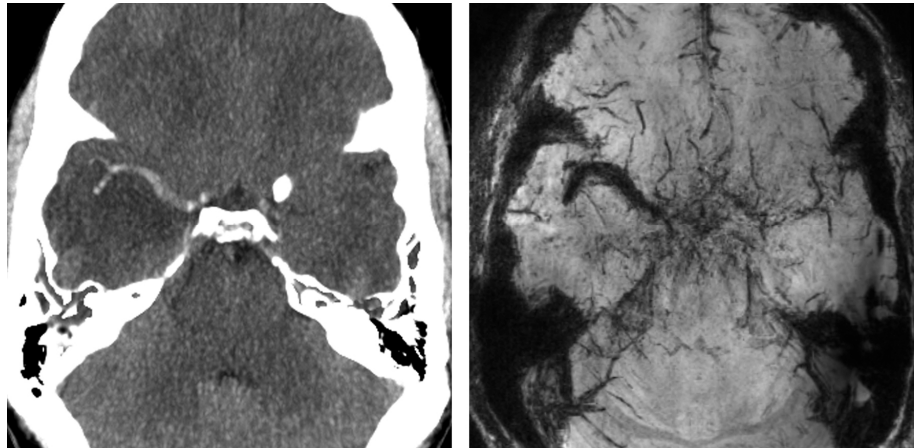


Figure: conventional non-contrast CT scan (left) and second echo T₂* weighted 7.0 Tesla MR image (right) of a patient with an acute cerebral infarct. The CT scan shows a hyperdense vessel sign of the right middle cerebral artery; the associated occluding thrombus can easily be identified on the T₂* weighted scan.

¹ Visser et al. Magnetization prepared 3D FLAIR imaging at 7.0 Tesla. Proceedings 17th Scientific Meeting, ISMRM 2009: 1472