

Comparative magnetic resonance imaging at 3T und 7T for the evaluation of diffuse axonal injuries

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Target audience: Clinicians and supporting scientists interested in clinical MRI at ultra-high magnetic field strength.

Introduction: Diffuse axonal injury (DAI) is a traumatic brain damage caused by cortical-subcortical shearing of axons and small vessels due to rotational acceleration/deceleration of the head¹. DAI is associated with loss of consciousness and extended coma after brain injury without confirmable mass lesion². This study aims to compare DAI-associated traumatic microbleeds (TMBs) and posttraumatic white matter lesions at 3 T and 7 T magnetic resonance imaging (MRI) to evaluate possible diagnostic benefits of 7 T MRI.

Methods: 8 volunteers (2 men, 6 women, age range 19 to 73 years (y), mean age 42 y) with DAI were prospectively enrolled at a median time interval of 75 months after traumatic brain injury. All study participants were examined with MR whole-body scanners at 3 T (Skyra, Siemens Healthcare, Erlangen, Germany) and 7 T (Magnetom 7 T, Siemens, Erlangen, Germany) in combination with 32-channel head coils (3 T: receive only, Siemens, Erlangen, Germany; 7 T: transmit/receive, Nova Medical, New York, USA). TMBs were registered on susceptibility weighted images (SWI) (3 T: voxel size (V) = 0.7x0.8x2.6 mm³, acquisition time (TA) = 4:03 min; 7 T: V = 0.7x0.7x2.0 mm³, TA = 4:10 min and V = 0.25x0.25x1.5 mm³, TA = 13:34 min). Posttraumatic white matter damage was compared on PD/T2-weighted images (3 T: V = 0.4x0.4x5 mm³, TA = 2:56 min; 7 T: V = 0.5x0.5x3 mm³; TA = 3:20 min). Lesion count was performed by two radiologists in consensus and evaluated by a Wilcoxon signed-rank test.

Results: Susceptibility-weighted images of similar spatial resolution depicted 310 TMBs at 3 T (range 2 - 127, median 31) and 397 TMBs at 7 T (range 3 - 176, median 42, p = 0.012). For the SWI acquisition with 10-14 fold increased spatial resolution, 434 TMBs (range 3 - 181, median 45, p = 0.012) were seen at 7 T. PD/T2-weighted images visualized a similar number of gliotic lesions at both field strengths (range 0-9, median 3, p = 0.157).

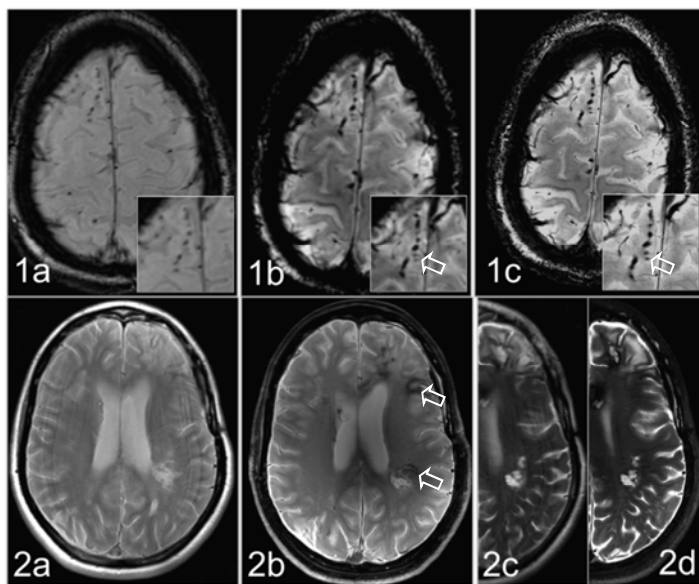


Figure 1: 7 T susceptibility weighted images with similar (b) and increased spatial resolution (c) depict more DAI-associated traumatic microbleeds (arrows) compared to 3 T SWI (a).

Figure 2: PD/T2-weighted imaging at 3 T (2a/2c) and 7 T (2b/2d) show comparable damage of the parenchyma after DAI and brain contusion, seen as CSF-isointense lesions, but only the 7 T PD-weighted image (2b) additionally reveals hypointense deposition of hemosiderin (arrows).

Discussion: TMBs are regarded as a neuroradiological marker for DAI, which can be detected years after head trauma. MRI is recommended in posttraumatic coma unexplained by CT scan for mainly three reasons: (1) diagnosis, (2) for assessing prognosis, and (3) for medicolegal reasons³. Although 1.5 T and 3 T MRI have been shown to be suitable for the detection of DAI⁴, the higher sensitivity of 7 T SWI for TMBs may improve diagnostics in critical cases.

Conclusion: 7 T SWI detects 28% more DAI-associated TMBs with similar and 40% more TMBs with increased spatial resolution compared to 3 T SWI. Hence, 7T MRI may be complementary to 1.5 T or 3 T MRI for the diagnosis of DAI in inconclusive or in medicolegal cases.

References:

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