

Microbleed Detection in Traumatic Brain Injury at 3T and 7T: Comparing 2D and 3D Gradient-Recalled Echo (GRE) Imaging with Susceptibility-Weighted Imaging (SWI)

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The detection of microbleeds (hemorrhages) is important for the diagnosis and prognosis of traumatic brain injury (TBI)^{1,2}. This study evaluated whether susceptibility-weighted imaging (SWI)³ improved microbleed detection in TBI patients over 2D or 3D gradient-recalled echo (GRE) imaging at 3T or 7T.

Methods

Twenty-four patients and three controls (21 men, 6 women, mean age 33.4 years, age range 19-54) were recruited and scanned on 3T or 7T GE Excite scanners. Five TBI patients scanned at 3T received a repeat scan 1 to 12 months after the first scan, for a total of 23 scans at 3T and 9 scans at 7T. Sixteen of the patients had mild TBI (Glasgow Coma Scale (GCS) 13-15), three moderate TBI (GCS 9-12), three severe TBI (GCS 3-8) and two of undocumented severity. The mean time from injury to MRI was 261 days (range 2 days to 3 years).

The 3D scans were spoiled GRE (SPGR) sequences with a 512x256x64 matrix and 1mm slice thickness. The TE/TR were 28/46ms at 3T and 16/80ms at 7T with a GRAPPA-like reconstruction (R=3) implemented within our laboratory. SWI images were created as described previously⁴. The 2D scan at 3T was a magnetization-prepared GRE (MPGR) sequence with 256x192x47 matrix, 3mm contiguous slices and TE/TR=15/500ms. The 2D scan at 7T was a GRE sequence with 512x512x10 matrix, 2/2mm slice/gap, TE/TR=11.4/250ms and NEX=3. Scan coverage was limited to regions included in both the 2D and 3D scans. A board-certified attending neuroradiologist blinded to the clinical data and image type counted the microbleeds in image sets presented in random order.

Results and Discussion

As shown in the Table below, SWI did not appreciably improve microbleed detection at 3T or 7T. The conspicuity of microbleeds increased in the 3D GRE imaging, although they remained clearly visible on the 2D GRE scans due to the heightened susceptibility weighting at high fields. Three main observations were made in relation to the results obtained with 2D and 3D GRE sequences.

2D scans were short and had high sensitivity to microbleeds:

The short scan time is especially important because the long 3D scans can be problematic in acute trauma patients or in patients with persistent, post-traumatic cognitive deficits. Even in these chronic TBI patients imaged in the outpatient setting there was serious motion degradation in 13% of the 3D GRE and SWI scans.

Venous structures were highly conspicuous in 3D scans:

3D scans showed that three suspected microbleeds in 2D scans corresponded to veins (see Table). On the other hand, the high conspicuity of venous structures perpendicular to the scan plane was reported as a complicating factor that may hinder the visual detection of microbleeds in routine practice (Fig 1). At present, the clinical significance of the load and spatial distribution of microbleeds remains uncertain², hence it is not clear if the additional sensitivity of 3D GRE and SWI outweighs the complexity that it introduces at high fields.

SWI introduced artifacts and did not improve microbleed detection:

Microbleeds stretched in the superior / inferior direction on SWI were frequently mislocated (e.g. microbleed located in ventricle in Fig 2B). Stretching was more pronounced at 7T than 3T. Artifacts due to failed phase processing were present in regions of high susceptibility (e.g. over frontal sinuses in Fig 2C). The difference between the 3D GRE and SWI scans was more pronounced at 3T than at 7T, as expected since susceptibility effects in the 3D GRE scans increase with field strength. The finding that SWI does not detect appreciably more microbleeds than 2D GRE differs from a previous study at lower fields¹ comparing 2D GRE with slice gaps to 3D SWI with a longer TE and minimum-intensity projection (MIP) and suggests that it is not the SWI-processing but rather the acquisition parameters that drive high-field microbleed detection.

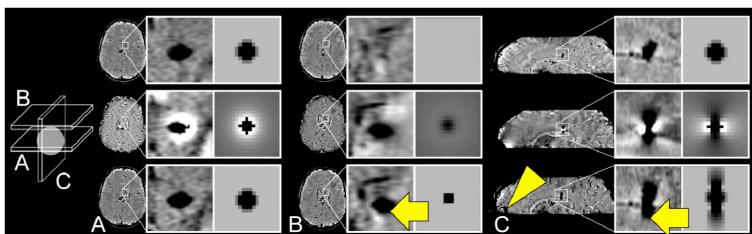


Figure 2. In-vivo (left inset) and simulated (right inset) GRE magnitude (top), GRE phase (middle) and SWI (bottom) images at 7T of (A) axial slices transecting, (B) axial slices adjacent to and (C) sagittal slices transecting the microbleed. In SWI the microbleed is stretched in the superior-inferior direction (arrow in C), mislocating the microbleed in a ventricle (arrow in B). SWI also had artifacts from failed phase unwraps (arrowhead in C).

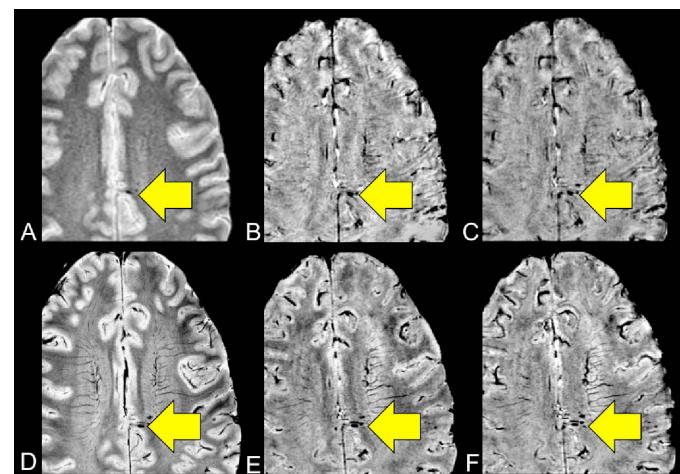


Figure 1. 3T (A-C) and 7T (D-F) 2D GRE (A,D), 3D GRE (B,E) and 3D SWI (C,F) of a patient scanned at both 3T and 7T. The yellow arrow indicates a region of microbleeds.

Type	3T MRI (N = 23)			7T MRI (N = 9)				
	Scan Time	Count		Scan Time	Count			
		0	1-5	5+		0	1-5	5+
3D GRE	13 min	12 4		7	8 min	5	2	2
3D SWI	13 min	12 4		7	8 min	5	0	4
2D GRE	1.6 min	9 7*		7	6.3 min	5	1	3

Table of microbleed counts. *Three false positives in the 3T 2D scans were shown to be vascular structures by comparison to the 3D scans, making the actual count identical to the 3D GRE and SWI.

Conclusion

Microbleeds were readily detectable in the short 2D GRE scans at 3T and 7T. Few or no additional lesions were detected with 3D GRE or SWI. Although additional study is required in a larger cohort, this suggests that the longer scan times required for 3D GRE and the additional post-processing for SWI may not be necessary for clinical practice of microbleed detection at high field.

References & Acknowledgements

¹Akter, Acad Radiol 2007, ²Scheid, J Neurotrauma 2007, ³Haacke, Magn Res Med 2004, ⁴Lupo, MRI 2008.

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