Six-Fold 2D-SENSE Accelerated Intracranial Contrast-Enhanced MR Venography --- A Comparison Between 1.5T and 3T

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Introduction Contrast-enhanced venography (CE-MRV) of the intracranial vasculature is used to diagnose sinus thrombosis [1]. The requirement of sub-millimeter high spatial resolution and whole-brain coverage typically leads to a scan time between 4 to 6 minutes. The tradeoff between resolution, acquisition time, and the limited temporal duration of the first-pass of the contrast bolus in 3D CE-MRV presents an ideal scenario for parallel imaging --- Sensitivity Encoding (SENSE) [2]. The purpose of this study is to prospectively compare identical 3D CE-MRV acquisitions at 1.5T and 3T using eight-element coil arrays and a 2D-SENSE acceleration of 6.4×. While a drawback of SENSE is unavoidable SNR loss, the higher signal baseline afforded by 3T offers the potential for improved SENSE performance [3, 4] while maintaining image quality for diagnostic use. We hypothesize that 6.4× accelerated CE-MRV examinations at 3T provide superior vessel conspicuity than corresponding 1.5T acquisitions.

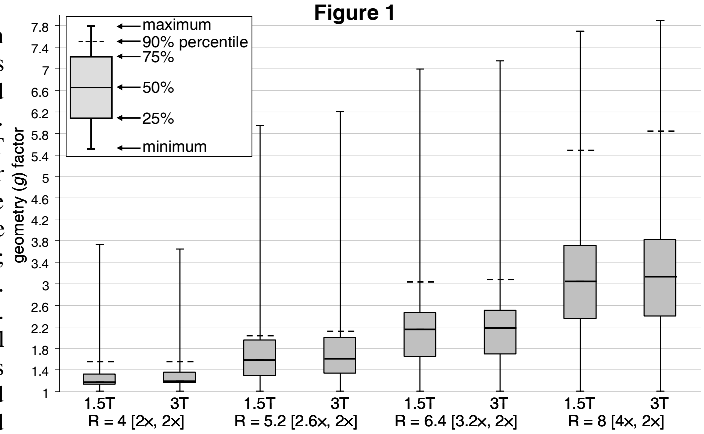
Methods 1.5T and 3T MR scanners (GE Medical Systems) used in this study were equipped with eight receiver channels. Two eight-coil head arrays of similar design were utilized, one for each field strength. All acquisition parameters, including contrast volume and injection rate, were kept constant between the two field strengths (3D gradient-echo pulse sequence, elliptical centric view order, TR/TE=6/2.3 ms, flip angle=30°, frequency-S/I, phase-A/P, slice-R/L, 320×320×176 sampling matrix, $FOV_{S/I}=FOV_{A/P}=25$ cm, 1 mm partitions ($FOV_{R/L}=17.6$ cm), voxel size = 0.8×0.8×1 mm^3, 19 ml Multihance at 3 ml/s, 25 ml saline at 2 ml/s). The non-SENSE scan time was 5 min 38 sec; with 6.4× SENSE, the time was reduced to 56 sec.

Phantom Studies – To evaluate SENSE performance, geometry (g) factors [2] were calculated from coil sensitivity maps acquired using a spherical phantom (diameter = 20 cm) filled with $NiCl_2$. At both 1.5T and 3T, g-factors were calculated for 2D-SENSE accelerations of 4, 5.2, 6.4, and 8.

In Vivo Studies – To date, six consecutive volunteers underwent 3D CE-MRV examinations. Each volunteer was scanned on two separate days, once at 1.5T, and once at 3T. Two neuroradiologists in consensus evaluated both 1.5T and 3T results on the basis of vessel conspicuity and overall image quality. For vessel conspicuity, intracranial veins were divided into two groups --- medium and large sinuses, and small deep and superficial veins. A five-point comparison scale was used for evaluation (*-2*=1.5T markedly better … *0*=1.5T and 3T equivalent … *2*=3T markedly better).

Results Geometry factors calculated from the phantom studies are shown in Figure 1 as box plots. Each box plot represents the distribution of g-factors within the 3D phantom at a particular 2D-SENSE acceleration and B_0 field strength. The inset on the upper left corner illustrates the box plot notations. No statistically significant difference in g-factors was found between 1.5T and 3T for any of the four accelerations considered (t-test). This further emphasizes the primary dependence of g-factors on coil array geometry. The mean and standard deviation of g-factors at 1.5T and 3T for 4× SENSE were 1.26±0.17 and 1.28±0.17, respectively; for 5.2×, 1.63±0.35 and 1.63±0.36; for 6.4×, 2.19±0.73 and 2.25±0.78; and for 8×, 3.23±1.29 and 3.36±1.38. Figure 2 shows full-volume maximum intensity projections from a volunteer. Both 1.5T and 3T images show comparable visualization of the intracranial venous system. However, thinner-volume (~2 cm thick) targeted projections in Figure 3 demonstrate improved vessel conspicuity (arrows) and improved vessel-background signal contrast at 3T than 1.5T. All images are displayed on the same window/level. Table 1 summarizes the evaluation scores. Visualization of large and medium sinuses were deemed equivalent between the two field strengths. However, all 3T results demonstrated better vessel conspicuity of smaller cerebral veins than corresponding 1.5T results. While all 1.5T images were considered excellent in diagnostic quality, preference was given to the corresponding 3T images in all six studies.

Figure 1



Conclusion Fast (< 60 sec), high-spatial-resolution (0.64 mm^3) 3D CE-MRV can be routinely achieved at 3T with 6.4× 2D-SENSE, which offers better vessel conspicuity and signal contrast than at 1.5T. 2D-SENSE CE-MRV has the potential to become the method of choice for fast visualization of the intracranial venous vasculature.

Figure 2

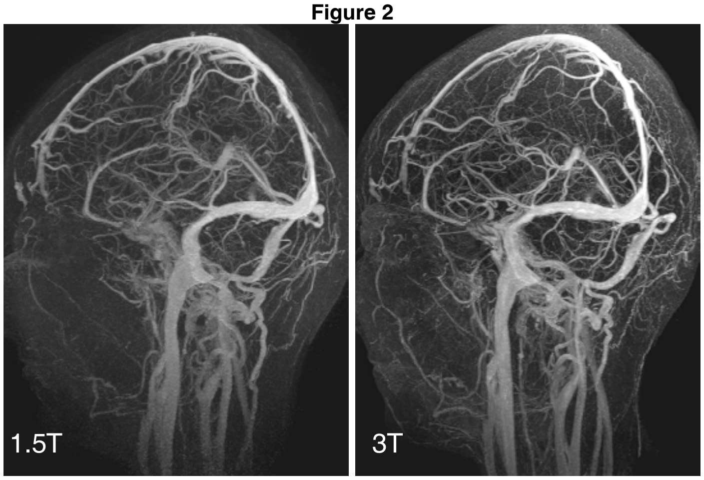


Figure 3

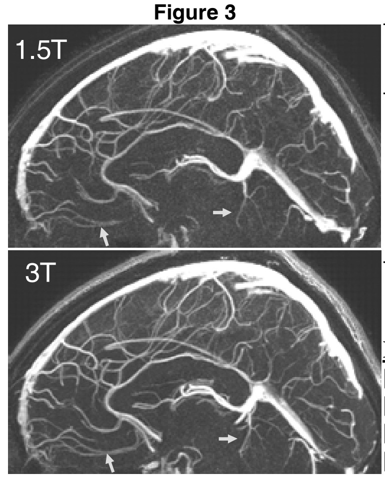


Table 1

Study	Large & Medium Sinuses	Small Deep & Superficial Veins	Diagnostic Image Quality
1	0	1	1
2	0	1	1
3	0	1	1
4	0	1	1
5	0	1	1
6	0	1	1

References
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