Quantitative Analysis of Contrast Efficiency of Phase Sensitive T1IR and Its Primary Applications to Neuroimaging

P. Hou[1], K. M. Hasan[1], C. W. Sitton[1], J. S. Wolinsky[2], P. A. Narayana[1]

[1]Department of Radiology, University of Texas Medical School at Houston, Houston, Texas, United States, [2]Department of Neurology, University of Texas Medical School at Houston, Houston, Texas, United States

Introduction Inversion recovery (IR) spin echo sequence produce brain images with excellent GM-WM contrast [1]. In general, these images are magnitude reconstructed. However, routine use of this sequence is limited because of its long scan time. With slice interleaving [2] and phase-sensitive reconstruction [3-4], IR sequence can provide brain images with excellent GM and WM contrast in short acquisition time. However, it is not clear if the phase sensitive reconstructed images with shorter acquisition times are diagnostically more useful relative to the conventional magnitude spin echo T1-weighted (T1SE) images. The purpose of this study is to quantitatively analyze the time efficiency and contrast enhancement and demonstrate its potential applications in various neurological disorders.

Methods A fully interleaved T1-weighted Inversion Recovery (T1IR) sequence (GE product T1IR source code) was modified to enable phase sensitive reconstruction (PS-T1IR). Performance of this sequence was quantitatively compared with the T1SE and magnitude reconstructed T1 weighted IR sequences (M-T1IR). Five healthy volunteers were scanned with SE, M-T1IR and PS-T1IR sequences on GE 1.5T clinical scanner (GE Healthcare, Milwaukee, WI). The values of TR and TI were optimized for good GM-WM contrast and maximize the number of slices in the shortest scan time. The optimized values are: for SE, TE/TR=14/500msec, scan time = 3:28; for M-T1IR, TE/TI/TR = 11.5/977/2250msec, scan time = 2:38; for PS-T1IR, TE/TI/TR = 11.5/430/2250msec, scan time = 2:33. The image matrix was the same for M-T1IR, T1SE and PS-T1IR: 256 x 192 constructed to 256x256, 24 cm field-of-view (FOV), 3mm slice thickness, 42 interleaved slices to cover the whole brain.

For quantitative comparison of different sequences, the contrast efficiency, η_{ij}, is defined as the contrast-to-noise ratio (CNR) between two tissues i and j divided by the square root of the scan time: $\eta_{ij} = CNR_{ij}/sqrt(scantime)$. A student t-test was used to compare the significance of contrast efficiency between different sequences. The performance of the sequence was evaluated on five normal volunteers and twenty patients with various neurological disorders. The phase sensitive reconstruction method built into the GE Signa scanner is not routinely available for clinical use. Some unexpected intensity inversions from slice-to-slice were observed. We have incorporated an edge detection algorithm in Matlab to automatically invert these images and they were automatically exported back to the browser on the scanner almost in real time by applying a trigger at the end of data acquisition.

Resutls These images were reviewed by a neuroradiologist, who felt that PS-T1IR provided the best diagnostic quality images. The results of the quantitative analysis are summarized in Table 1. PS-T1IR is more time-efficient compared to T1SE and generates better GM -WM contrast, especially between internal capsule and putamen, as shown in Figure 1. This sequence provided the best CNR efficiency (1.16) compared to M-T1IR (0.73) and T1SE (0.23), as shown in Table 1. Patient studies further demonstrated the improved GM-WM contrast and higher gadolinium contrast enhancement, as shown in Figure 2. For a typical clinical protocol (19-21 slices, 5mm slice thickness, 256x192), PS-T1IR takes only 1:30 minutes vs. 2:40 minutes for T1SE imaging for whole brain coverage.

Table 1: Contrast efficiency*

Technique	PS-T1IR	M-T1IR	T1SE
Scantime (minute)	2:33	2:38	3:28
η_{12}	1.159±0.086	0.729±0.169	0.232±0.115
p		0.0010	0.0000
η_{15}	0.908±0.174	0.398±0.152	0.120±0.118
p		0.0012	0.0000
η_{32}	1.198±0.092	0.729±0.160	0.156±0.151
p		0.0005	0.0000
η_{45}	0.816±0.147	0.407±0.276	0.097±0.099
p		0.0193	0.0000
η_{42}	1.067±0.111	0.738±0.164	0.209±0.125
p		0.0059	0.0000

* The values are mean ±sd. 1 - corpus callosum, forceps minor; 2 - caudate nucleus, head; 3 - corpus callosum, genu; 4 - internal capsule, genu; 5 – putamen

Conclusion

PS-T1IR has the highest CNR efficiency compared to M-T1IR and T1SE. It is a very practical sequence for routine neuroradiological applications.

References [1]Young IR et al. *Magn Reson Med* 1985; 2: 81-85. [2]Listerud J et al. *Magn. Reson. Med*. 1996; 36:320-325. [3] Xiang QS, *J. Magn. Reson. Imaging* 1996;

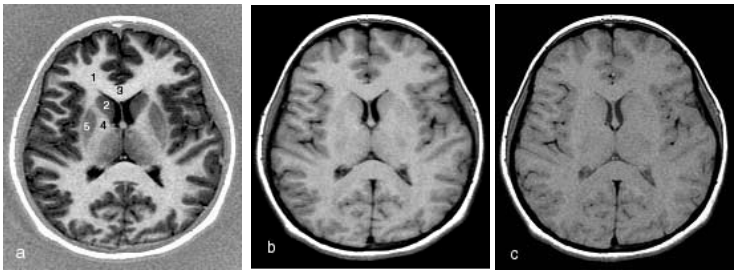

Figure 1. Improvement in GM-WM contrast with PS-T1IR sequence in a normal volunteer. The PS-T1IR demonstrates excellent GM-WM contrast along with CSF suppression and shortest scan time of 2:33 (a). The worst image contrast is seen on routine T1SE with longer scan time of 3:28(c). The contrast observed in M-T1IR is between T1SE and PS-T1IR with scan time of 2:38(b).

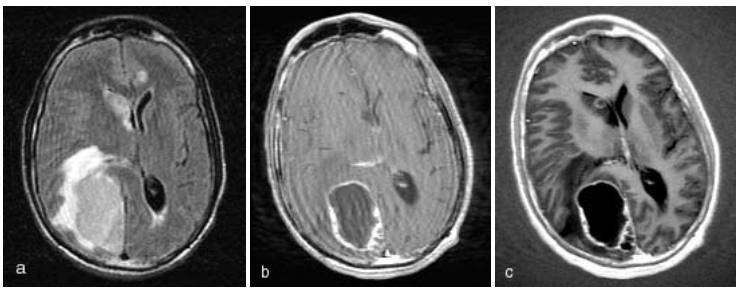

Figure 2. Images from a patient with multiple cerebral abscesses. Several well circumscribed mass lesions with perilesional edema are seen on the T2 FLAIR (a); Post Gd scan of T1SE (scan time of 2:28) (b) and PS-T1IR (scan time of 1:25) (c) demonstrate the lesion perfusion area. The lesion was hypointense in PS-T1IR and hyperintense on T2FLAIR. Again the superior contrast obtained with PS-T1IR relativeT1SE can be observed on this figure.