# Evaluation of 3D-EPI PULSAR with and without Background Suppression Inversion Recovery Pulse

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## Introduction

Modification of the recently introduced PULSAR technique [1] by use of a non-selective inversion pulse along with 3D-Turbo Field EPI (TFEPI) acquisition, labeled IR-3D-PULSAR (for CSF suppressed Inversion Recovery), is described here. Single-shot 3D acquisition schemes eliminate slice dependent variation of the perfusion signal seen in 2D multi-slice images due to different acquisition delay times [2].Previously, it has also been shown in the context of projection angiography [3] and segmented acquisition FAIR and CASL approaches [4] that use of inversion pulses results in superior temporal stability of $\Delta M$ images by reducing the background signal. Other related works include 3D fMRI using single-shot spirals with FAIR [5] and 3D-GRASE with CASL [6] and with FAIR [7]. However, it is not clear whether the use of such inversion pulses will lead to quantifiable reduced temporal variation with single-shot 3D-TFEPI acquisition schemes. Our results indicate that the use of even a single non-selective inversion pulse (hyperbolic-secant pulse) leads to greatly improved background suppression and reduced temporal variability of $\Delta M$ images

## Materials and Methods

The PULSAR sequence was modified as shown schematically in Figure 1. The two implementations were identical except that for IR-3D-PULSAR, following WET pre-saturation, "tagging" or "control" adiabatic inversion pulse(s) and post-saturation pulse, a non-selective inversion pulse was introduced. The TI time was determined by simulation so as to suppress CSF for the given TR. The modified sequence was implemented on a Philips 3T Achieva scanner (Release 1.5.4 software). Five healthy volunteers were scanned under an IRB approved protocol. IR-3D-PULSAR and 3D-PULSAR parameters were: TR/TD=2040/1500 ms; 60 pairs of control/label images; data acquisition: 3D-TFEPI with 24 slices, 4mm slice thick., 64×64 matrix, SENSE factor=2; DAC window≈450ms; scan time: 4 min 5 s. For IR-3D-PULSAR, the TI time was fixed at 720 ms prior to data acquisition. As shown in [4], introduction of $N$ inversion pulses, results in $\Delta M^*(t) = (-1)^N \Delta M(t)$. Thus, $\Delta M^*(t)$ for the IR-3D-PULSAR acquisition was calculated using *(Label – Control)* instead of *(Control – Label)* images. The acquired $\Delta M(t)$ images were analyzed for temporal stability of the perfusion signal by calculating $\langle \sigma(\Delta M(t)) \rangle / \langle \Delta M(t) \rangle$ for ROIs in grey matter (GM), white matter (WM), CSF and for the whole brain (Glo). All ROIs and slices were matched for both sequences.

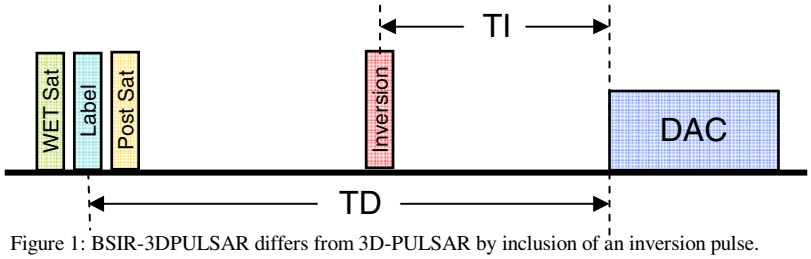


Figure 1: BSIR-3DPULSAR differs from 3D-PULSAR by inclusion of an inversion pulse.

## Results

Figure 2 shows every fourth slice of the 24 slices acquired with IR-3D-PULSAR. Table 1 shows the values for $\langle \sigma(\Delta M(t)) \rangle / \langle \Delta M(t) \rangle$ averaged over all five volunteers. There was a considerable reduction in this measure for IR-3D-PULSAR as compared with 3D-PULSAR. Note that $\Delta M(t)$ values in WM and CSF were small, resulting in high ratios of $\langle \sigma(\Delta M(t)) \rangle / \langle \Delta M(t) \rangle$.

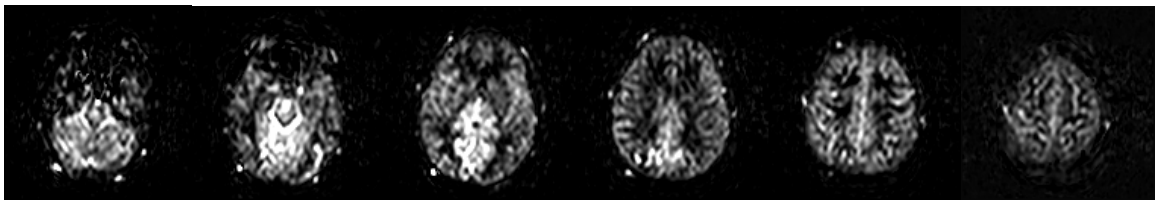

Figure 2: Every fourth slice of 24 slices acquired with IR-3D-PULSAR.

| **TABLE 1** | $\langle \sigma(\Delta M_{GM}) \rangle / \langle \Delta M_{GM} \rangle$ | $\langle \sigma(\Delta M_{WM}) \rangle / \langle \Delta M_{WM} \rangle$ | $\langle \sigma(\Delta M_{CSF}) \rangle / \langle \Delta M_{CSF} \rangle$ | $\langle \sigma(\Delta M_{Glo}) \rangle / \langle \Delta M_{Glo} \rangle$ |
|---|---|---|---|---|
| 3D-Pulsar | 2.35±1.14 | 33.7±26.7 | 13.77±10.84 | 1.35±0.27 |
| IR-3D-Pulsar | 0.996±0.288 | 5.25±3.15 | 6.11±2.14 | 0.613±0.22 |

## Conclusions

The inclusion of the inversion pulse in 3D-PULSAR results in higher temporal stability of $\Delta M$ images. The use of even a single inversion pulse between the tagging/control pulse(s) and data acquisition therefore proves greatly beneficial.

## References

[1] X. Golay et al. *MRM*, 53:15-21, 2005. [2] L. Talagala et al. *ISMRM*, 2006: 3422 [3] S. Mani et al. *MRM* 1997; 37:898-905. [4] F. Ye et al. *MRM*, 44 :92-100, 2000. [5] G. Duhamel et al., *ISMRM*, 2004: 518. [6] M. Fernandez-Seara et al. *MRM* 2005; 54: 1241-1247. [7] M. Günther et al. MRM 2005 ; 54 : 491-498.