**3D DIR: 3D Double Inversion Recovery in Multiple Sclerosis**

P. Polak¹, R. Zivadinov¹,², and G. Poloni¹

¹Buffalo Neuroimaging Analysis Center, Department of Neurology, University at Buffalo, State University of New York, Buffalo, NY, United States; ²The Jacobs Neurological Institute, Department of Neurology, University at Buffalo, State University of New York, Buffalo, NY, United States

**OBJECTIVE:** To implement an improved 3-dimensional (3D) Double Inversion Recovery (DIR) sequence to enhance lesion detection in MS patients in white (WM) and grey matter (GM).

**BACKGROUND:** Diagnosis and prognosis of multiple sclerosis (MS) is currently strongly based on magnetic resonance imaging (MRI) outcomes, which conventionally includes T₂-weighted (T₂W), and pre- and post-contrast T₁-weighted (T₁W) imaging. (Zivadinov and Cox, 2007) Double Inversion Recovery (DIR) sequences have been proven to enhance lesion detectability in both WM and GM. (Geurts et al., 2005; Redpath and Smith, 1994) With the introduction of long echo-train (ET) lengths with single-slab prescriptions (Mugler et al., 2000) and the consequent reduced acquisition time demands, 3D sequences are clinically viable. DIR commonly aims to suppress CSF and WM while leaving signal from lesions and GM, with low signal-to-noise ratio (SNR) an inherent issue; however, the increased contrast-to-noise ratio (CNR) between the lesions and the background tissue can outweigh this problem. 3D DIR sequences display superior sensitivity to clinically significant lesions in both the GM and WM, thereby helping resolve the clinical/radiological paradox in MS. (Zivadinov et al., 2008)

**METHODS:** 3D DIR was developed on a 3T GE scanner (General Electric, Milwaukee, WI) using an experimental approach based on theoretical double inversion recovery dynamics and T₂ relaxation principles. Series of sequences with varying imaging parameters (TEᵢeff, TR, T₁₁, T₁₂) were run on a clinically-definite MS volunteer. ROI analyses were conducted in the areas of CSF, WM, GM and lesions, and the signal intensities were graphically plotted in order to determine a “best guess” of the optimum sequence parameters. A further set of sequence parameters, centered on the previous estimates were then imaged and analyzed in a similar fashion on another volunteer to produce a better estimate. This experimental approach was iterated over a set of ten MS volunteers in order to produce the optimum set of sequence parameters.

**RESULTS:** The following parameters were established for optimum lesion detection: TR=7000ms, TEᵢeff=190ms, T₁₁=2300ms, T₁₂=480ms, FOV=280mm, acquisition matrix=256x256, slice thickness=2mm, echo train length=256, averages=2, acquisition time=10min for full brain coverage. Lesion visibility is highlighted in three main areas: spinal cord region (Figure 1A), periventricular and possibly deep GM (Figure 1B), and small lesions in deep WM (Figure 1C). While these DIR parameters are optimal for 3T and a particular ET variable flip angle algorithm, this method can easily be extended for any magnet strength and ET signal intensities in order to produce an optimal set of sequence parameters.

**CONCLUSIONS:** The optimized DIR sequence described has an improved lesion detection power, being able to highlight smaller lesions in the WM due to the WM signal attenuation. Lesions in the GM and in the spinal cord are also detectable, and are potentially more clinically significant than the WM signal alterations. 3D DIR can contribute to a better understanding of the “clinical/radiological paradox” and may be soon introduced as part of the conventional MRI protocol for the diagnosis and prognosis of MS.

**REFERENCES**


