Improved Fat Suppression Homogeneity of mDIXON TSE Total Spine Imaging compared to SPIR Fat Saturation for Post-Contrast T1-weighted Imaging at 3.0T

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Target Audience Clinicians who perform whole spine MRI exams that utilize fat suppression.

Purpose Homogeneous fat suppression is often challenging in large field of view post contrast MR imaging of the spine. Loss of signal due to magnetic field inhomogeneity and incomplete fat suppression especially at the limits of field of views is not an uncommon occurrence and is potentially clinically relevant. An alternative to traditional spectral saturation or inversion recovery fat suppression are the chemical shift based fat suppression techniques commonly known as Dixon water fat separations. These techniques use the phase differences of water and fat occurring at variable TE's to create images highlighting water or fat as well as in and out of phase conditions. Specifically, the modified Dixon (mDIXON)[1] fat suppression that was used in this study is a 2 point technique which can be added to both T1- and T2-weighted Turbo Spine Echo (TSE) sequences. Compared to other Dixon methods, this technique is unique based on its use of only 2 acquisitions with unrestricted TEs, resulting in shorter scan time, less blurring and improved spatial resolution with shorter TSE shot lengths then required by other similar available Dixon methods. To the best of our knowledge, to-date no studies have been published describing the clinical use and improved image quality of mDIXON in fat suppressed MR spine imaging. Therefore, the purpose of this study is to quantitatively assess the improved image quality of post contrast total spine MR imaging with fat suppression performed using mDIXON compared to the more traditional Spectral Presaturation with Inversion Recovery (SPIR) fat saturation.

Methods Institutional review board waiver permission was obtained for this study. The post contrast total spine images of ten pediatric patients who underwent clinical MR imaging were randomly identified. Total spine imaging was performed with a 3T MR imaging system (Ingenia 3T; Philips Healthcare, Best, The Netherlands). As components of the routine institutional clinical protocol for post contrast total spine imaging, sagittal 2D T1-TSE fat suppressed images were obtained with both SPIR and mDIXON. For each method, the following imaging parameters were identical: FOV AP 180 mm FH 350 mm, 15 slices acquired with a slice thickness/gap 3.64/0.36 mm, turbo factor 6 with asymmetric k-space sampling, and echo spacing/TE 8 msec. For the SPIR images, TR = 550 msec, with a pixel bandwidth of 282 Hz, and three slice packages. For the mDIXON images, $\Delta TE = 1$ msec, with a pixel bandwidth of 698 Hz. A seven peak fat model[2] was used for the reconstruction of the water only images. Sensitivity Encoding (SENSE) of 1.7 was used in all imaging sequences. The average scan time was 2 min 12 sec for images performed with SPIR and 3 min 22 sec for images performed with mDIXON. Overall image quality and fat suppression effectiveness for the SPIR and mDIXON images were rated by two CAQ pediatric neuroradiologists on a scale from 0 (poor) to 3 (excellent), and analysed using a 2-tailed t-test to determine if there was a statistically significant difference in image quality and fat suppression between the respective image datasets.

Results For the ten patients in this study, the overall image quality was found to be significantly better ($p < 0.05$) with mDIXON TSE (2.0 +/- 0.5) compared to those scanned with SPIR TSE (1.4 +/- 0.5), while the mDIXON TSE (3.0 +/- 0.0) demonstrated significantly more effective fat suppression ($p < 0.001$) then the comparable SPIR TSE (1.4 +/- 0.8). Both neuroradiologists labeled all of the post contrast mDIXON images as showing excellent fat suppression, while none of the post contrast SPIR images were given a similar rating. Figure 1 shows a comparison of one set spine SPIR and mDIXON images, along with the resultant subtraction of the images to accentuate the differences in the effectiveness of fat suppression. Note the enhancing lesion at T12 that is only seen in the mDIXON TSE image (arrow).

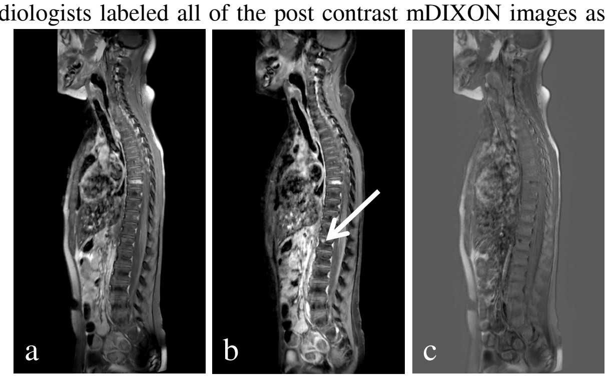

Figure 1. Acquired (a) 2D SPIR TSE, (b) 2D mDIXON TSE images. (c)Subtraction of image b from image a showing image intensity variation between SPIR and mDIXON. Note the enhancing lesion (arrow) in (b) that is not seen in (a).

Discussion The results of our study show that post contrast total spine sagittal MR images performed with mDIXON demonstrated significantly less fat suppression failure and inhomogeneity than similar images performed with standard fat saturation methods (SPIR). Our results are clinically significant for a number of reasons. First, the results show that the application of mDIXON to post contrast spine imaging fundamentally provides a solution for the fat suppression failure and image inhomogeneity which commonly occur in routine post contrast clinical MR spinal imaging. The occurrence of these artifacts is one of the most important reasons why many radiologists prefer to avoid utilizing 3.0 T for spinal MRI and the routine application of fat suppression on post contrast imaging. Local variations in tissue type as well as body habitus can influence the degree of fat suppression failure and inhomogeneity observed in a given patient. mDIXON fat suppression results in a more uniform soft tissue signal intensity, yielding proper image quality, lesion detection (when applicable) and increased patient-to-patient image quality reproducibility. We believe that the application of mDIXON fat suppression enables spinal MRI at 3.0 T to be performed with similar accessibility, consistency, and level of utilization as at 1.5T, while taking full advantage of the higher signal-to-noise ratio of 3.0 T to either enhance the image spatial or temporal resolution, or both.

Conclusion. The use of mDIXON fat suppression eliminates patient-to-patient variations in image quality of spinal MRI at 3.0 T, and will likely increase the accessibility and level of utilization of 3.0T for spinal MRI.

References 1. Eggers H, Brendel B, Duijndam A, Herigault G, Magnetic Resonance in Medicine. 2011;65(1):96-107, 2. Ren J, Dimitrov I, Sherry A D, Malloy C R, Journal of Lipid Research, 2008;49(9):2055-2062.