

## Assessment of T1 $\rho$ Mapping of Thoracolumbar Discs at 3T with and without RF Shimming

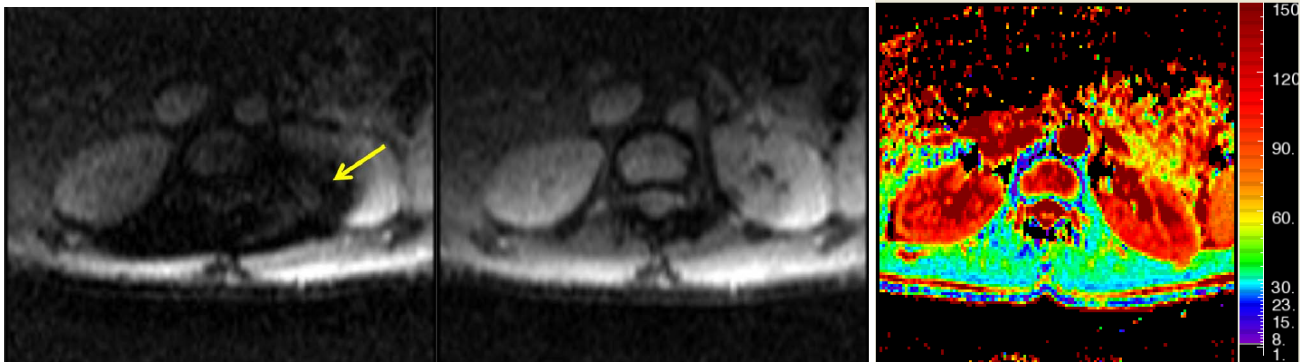
Trevor Andrews<sup>1,2</sup>, Richard Watts<sup>2</sup>, Scott Hipko<sup>2</sup>, Jay Gonyea<sup>2</sup>, and Christopher Filippi<sup>2,3</sup>

<sup>1</sup>Philips Healthcare, Cleveland, OH, United States, <sup>2</sup>Radiology, University of Vermont College of Medicine, Burlington, VT, United States, <sup>3</sup>Radiology, Fletcher Allen Health Care, Burlington, VT, United States

**Introduction:** Previous investigators have studied the use of T1 $\rho$  to assess proteoglycan (PG) content in cartilage as a means for early detection of cartilage degeneration (1). To accomplish accurate T1 $\rho$  estimates, spin locking pulses have been developed to be relatively robust with B1<sup>+</sup> and B0 inhomogeneities. It has been shown that there can be substantial B1<sup>+</sup> inhomogeneity near the thoracolumbar junction of the spine, and that this can be reduced with RF shimming enough to significantly reduce image quality defects in traditional radiological MR imaging of the spine (3). In this work we investigate the performance of previously developed spin locking pulses in the thoracolumbar spine with and without RF shimming.

**Methods:** Data Acquisition: Motion-free images were acquired on 5 healthy volunteers using a Philips 3T TX MR system (Philips Healthcare, Best, Netherlands). A sagittal T2W turbo spin echo (TSE) scan was performed with the following parameters: TE/TR = 2800/110ms, flip=90deg, FOV = 240x240mm, thickness=3mm, 18 slices, matrix=480x480. For the T1 $\rho$  acquisition, an axial 3D turbo field echo acquisition centered on the T12/L1 disc was repeated with five spin lock times (TSL): TR/TE = 3.35/1.76ms, flip=10°, 240x240mm, thickness=3mm, 18 slices, matrix=160x160, TSL=1/25/50/75/100ms, spin lock frequency = 350Hz. The spin locking pulse was a 90x-( $\tau/2$ )y-180y-( $\tau/2$ )y-90x composite pulse described previously (2). To estimate B1<sup>+</sup> both with and without RF shimming, the dual interleaved TR method was used (4). Analysis: For T1 $\rho$  analysis T1 $\rho$ -weighted data was fitted to a monoexponential function for each pixel and T1 $\rho$  maps were calculated. In addition the central slice of the T1 $\rho$ -weighted data was selected and an ROI was drawn within the nucleus pulposus in the center of the disc on the TSL=100ms image so that the ROI was also within the disc on adjacent slices (to minimize partial volume averaging with other tissues). Corresponding ROIs were drawn on the B1<sup>+</sup> maps.

**Results:** A clear rippling artifact was seen in all unshimmed T1 $\rho$ -weighted data, which was absent in the RF shimmed acquisitions (Fig 1). In each case RF shimming produced T1 $\rho$ -weighted data which could be fitted to a monoexponential function to produce T1 $\rho$  maps. In 3 of the 5 cases the acquisitions without RF shimming could not be fitted to a monoexponential ( $R^2 < 0.2$ ), either pixelwise or with the ROI. For all RF shimmed cases the signal fit well to a monoexponential ( $R^2 > 0.95$ ). B1<sup>+</sup> values obtained were 69%-46% of the nominal value without RF shimming and 85%-88% with RF shimming.



**Figure 1:** T1 $\rho$ -weighted images and TSL=25ms, without RF shimming (left), with RF shimming (center), A typical RF shimmed T1 $\rho$  map (right).

**Discussion:** Without RF shimming gross banding artifacts were produced. While in all but one case the banding artifacts generally did not overlap the cartilage, anatomy posterior to the disc was obscured (Fig 1) and nominal B1 was low enough to cause the spin locking pulse to fail to create well defined T1 $\rho$ -weighting as seen in the poor exponential fits. These gross defects were not present in the RF shimmed acquisition, consistent with this interpretation.

**References:** (1) Johannessen W, et al, Spine, 2006; 31(11): 1253-1257. (2) Witschey W, et al., J Mag Res, 2007; 186(1): 75-85. (3) Filippi C., et al., Proc. RSNA, 2010. (4) Yarnykh VL., Mag Reson Med, 2007;57:192-200.