In vivo MR high resolution T1rho mapping of the spine at 3T using a reduced-FOV approach

A. Shankaranarayanan[1], E. U. Saritas[2], D. G. Nishimura[2], W. Chen[1], and E. Han[1]
[1]Global Applied Science Lab, GE Healthcare, Menlo Park, California, United States, [2]Dept of Electrical Engineering, Stanford University, Palo Alto, California, United States

Introduction: Back pain is one of the most common medical problems in the western world with lower back pain afflicting more than 50% of all individuals during their lifetime. Degenerative disc disease (DDD) (one of the known causes of back pain) is characterized by biochemical and morphologic changes in the intervertebral disc. It has been suggested that MR T1ρ relaxation time may potentially be valuable to assess proteoglycan (PG) loss in the early stages of disc degeneration (1). Various MR T1ρ techniques have previously been used in spine (2,3,4). Although the results have been promising, clinical applicability of these techniques in the spine is somewhat limited by either long scan time, lower resolution or insufficient coverage. This work aims to alleviate these limitations by applying a reduced-FOV technique, previously shown for diffusion imaging (5), to T1ρ imaging. In vivo experiments have been performed at 3T to show the usefulness of such a targeted approach in terms of higher resolution and shorter scan times while providing good coverage in the spine.

Methods: *Acquisition*: Pulse Sequence: A product spin echo EPI pulse sequence was modified for this study. The contrast from a non-selective magnetization preparation module (T1ρ) is maintained using the formulation described in (6). The 90° spectral spatial pulse in the acquisition is replaced by a 2D echo-planar RF (2D-EPRF) excitation pulse for obtaining the targeted excitation. This 2D-EPRF excitation pulse allows to reduce the FOV in the phase-encode (PE) direction, while suppressing the signal from fat simultaneously. The 2D-EPRF pulse durations were kept around 16 ms, to maximize the number of slices while avoiding long echo times (TE). A minimum-phase SLR design was employed with TBW_{Slice} =3. Finally, a TBW_{PE} of 10 was used to generate a sharp reduced-FOV profile. Single-shot EPI imaging was done since targeted excitation allows for higher resolution with lower distortions.
T1ρ prep: T1ρ- weighted images were acquired by varying the duration of the spin lock pulse (TSL). The spin lock pulse preparation is described in (7).
Experiments: After obtaining informed consent, the spines of healthy volunteers were scanned on a 3.0T Signa HDx system (GE Healthcare, Waukesha, WI) using an 8 channel CTL coil. Single shot EPI pulse sequence parameters: slice thickness = 4 mm; in-plane resolution = 0.93x0.93mm; 6-8 slices, NEX (NSA) = 64; partial ky and EPI ramp sampling. Scans were performed in both axial and sagittal planes. For quantitative T1ρ imaging (as mentioned in (5)): spin lock frequency = 300 Hz; TSLs = 0, 10, 40, 80, 100ms. Scan time for T1ρ imaging was ~10 min. Quantitative T1ρ maps were calculated using a two-parameter mono-exponential fit.

Results: Fig. 1 (a)-(e) shows sagittal T1ρ-weighted images in a healthy volunteer (35 year old male) for 5 different TSL's, with good signal to noise ratio (even for TSL = 100) and no significant artifact. Fig 1(e) illustrates the reconstructed T1ρ map overlaid on a TSL = 0 image. The T1ρ values were found to be 83.1±13.2ms, 91.9±9.1ms, 79.8±8.7ms, 93.5±11.6ms, 88.9±16.5ms for T12-L1, L1-L2, L2-L3 and L3-L4 disc respectively. Fig. 2 shows the reconstructed T1ρ map overlaid on the TSL = 0 image in the axial plane. The T1ρ values in the different regions of the disc as indicated by ROI's 1, 2 and 3 were found to be 90.3±24.3ms, 93.4±10.2ms, 80.5±16.1ms respectively .

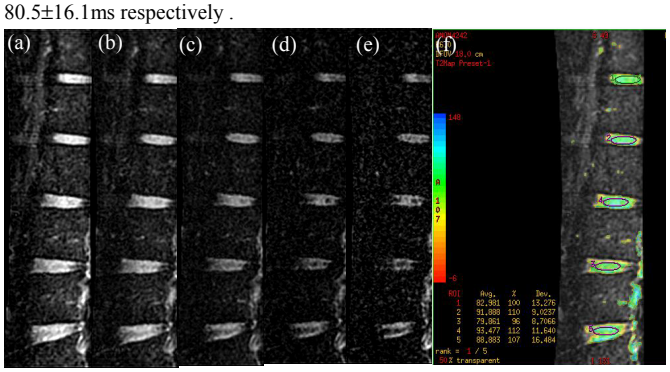

Fig. 1 *In vivo* T1ρ-weighted images (TSL=0/10/40/80/100ms) and reconstructed maps overlaid on TSL=0 image. (a)-(e) images from a healthy volunteer; (f) shows the T1ρ map. Note that mean T1 values for the different discs were obtained from the ROI's shown in the overlay image.

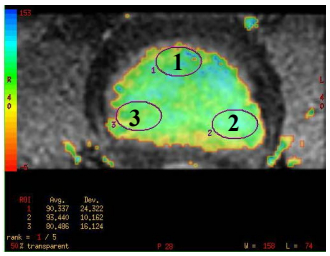

Fig. 2 *In vivo,* targeted T1ρ map in the axial plane. Image shows one slice from the multi slice acquisition

Discussion: In this preliminary study, we have developed a T1ρ mapping technique based on a reduced-FOV sequence and showed the feasibility to use it for *in vivo* T1ρ mapping in the spine at 3T. The single-shot technique has the potential to be more robust to pulsatile and other motion artifacts when compared to multi-shot techniques. It also can provide higher resolution T1ρ weighted images in reasonable scan times.

References: [1] Duvvuri U., et al., Magn. Reson. Med 1997: 38:863-867. [2] Blumenkrantz G., et al., ISMRM 2005. [3] Johannessen W., et al., ECM 2005. [4] X. Li et al, ISMRM 2009, [5] Saritas et al , MRM 60:468-473, 2008. [6] Wright et al. ISMRM 1996. [7] Li X., et al., Magn. Reson. Med. 2005, 54(4): 929-936.