Quantitative Reproducibility Initial Study of T1 Rho at 3T

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Introduction: Osteoarthritis is a prevalent degenerative joint disease, with radiographic disease in 80% of people over the age of 75 [1]. High field-strength MRI and new techniques, such as T1ρ, may provide a more sensitive means of assessing the degree of early damage to cartilage than plain film radiography or conventional MRI [2]. T1ρ describes the spin-lattice relaxation in the rotating frame and has been proposed for detecting damage to the cartilage collagen-proteoglycan matrix in osteoarthritis. The ability to detect the disease at an early stage and offer treatment or prevention methods would be of enormous benefit to the affected individuals.

The goal of this study is to determine the initial reproducibility and reliability of T1ρ mapping at 3-Tesla and determine the feasibility as a clinical tool. Reproducibility was studied sequentially on one machine as well as over time on multiple machines. These data are important to assure that accurate measurements are obtained and to determine if an external reference must be routinely evaluated for scanner calibration purposes.

Materials and Methods: A segmented magnetization-prepared 3D SPGR sequence [3] was used to acquire T1ρ-weighted images at 4 different TSL's – 0, 10, 30, 70 ms (spin lock frequency = 500 Hz). Three reference phantoms were developed using different agar concentrations (1%, 2%, 4%) [4] to represent a range of T1ρ values and were imaged repeatedly. A positioning apparatus was manufactured to hold each reference phantom and to minimize positioning errors between repeated studies. Two Signa 3 Tesla imagers (MR750, GE healthcare, Waukesha WI, USA) were used to acquire T1ρ data using an 8 channel phased array coil designed for knee imaging (GE Coils, Cleveland, OH, USA).
T1ρ acquisitions were repeated using a range of slice thickness (1-8 mm) and were used to validate the SNR measurement method used in this study; the signal was measured as the average of each phantom, and the noise was determined as the average of the standard deviation measured in the air at the corners of the image. SNR and T1ρ data were acquired 10 times in one setting to establish each measurement's reproducibility. SNR and T1ρ data were then acquired 7 times over a 14 day period on the two scanners to determine each measurement's reproducibility over time. The average T1ρ data were compared between the two scanners.

Results:

Table 1

		SNR		T1ρ	
	Tube	Mean	Std	Mean	Std
A	1	1225.01	35.22	22.05	0.07
	2	828.11	23.15	29.77	0.1
	3	1364.36	38.96	121.28	0.25
B	1	1307.26	26.35	20.99	0.07
	2	908.53	18.36	29.95	0.11
	3	1589.97	33.05	127.49	0.19

Table 2

		SNR		T1ρ	
	Tube	Mean	Std	Mean	Std
A	1	1225.42	53.99	20.63	0.74
	2	812.99	43.53	29.01	0.64
	3	1372.35	66.3	118.06	4.18
B	1	1184.26	55.06	20.98	0.56
	2	797.1	36.92	29.25	0.56
	3	1416.67	64.94	123.65	1.64

Table 1. Measurement of Reproducibility (10x, one setting) Scanner A: SNR measurement coefficient of variation (CV) = 2.87%, T1ρ CV= 0.32%; Scanner B: SNR measurement CV= 2.08%, T1ρ CV= 0.35%

Table 2. Measurement of Reproducibility (7x, over 14 days) Scanner A: SNR measurement CV= 5.35 %, T1ρ CV= 3.58%; Scanner B: SNR measurement CV= 4.65 %, T1ρ CV= 2.65%

Figure 1. 3 Phantom Relative SNR vs Nominal Slice Thickness Linear change in SNR for each of the 3 agar phantoms and validation of the measurement as a QC tool

Figure 2. T1ρ Scanner Regression T1ρ values for each of the 3 phantoms vary by less than 2% between the Scanner A and B

Figure 1

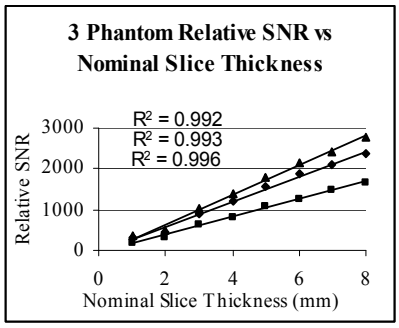
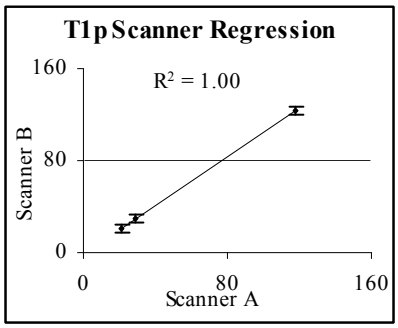


Figure 2



Discussion and Conclusion: Measurement reproducibility in the single setting was very high – CV on both scanners was less than 3% and 0.5% for SNR and T1ρ, respectively. Over time SNR and T1ρ were stable, with CV of less than 5.4% and 3.6%, respectively, derived over 14 days. T1ρ values measured on two different scanners compared well – differing by less than 1% for phantom 1, 0.5% for phantom 2, and less than 2% for phantom 3. Measurements of standard deviation and CV compared on one machine and across two machines were low enough to suggest that this tool is reliable and could be useful clinically in the setting of early disease changes.

References: [1] MP Recht, 1998 Topics in MRI 9(6): 328-336. [2] GE Gold, 2006 Orthopedic Clinics of North America; 3793: 331-347. [3] X Li, 2008 Magnetic Resonance in Medicine; 59:298-307[4] X Li, 2005 Magnetic Resonance in Medicine; 54:929-936