

## Sensitivity of T1 $\rho$ MRI and Pfirrmann Grade to Discogenic Pain

Matthew Fenty<sup>1</sup>, Catherine DeBrosse<sup>2</sup>, Rachelle Crescenzi<sup>2</sup>, Dawn Squillante<sup>3</sup>, Philip M. Maurer<sup>3</sup>, Dawn M. Elliott<sup>4</sup>, and Ari Borthakur<sup>1</sup>

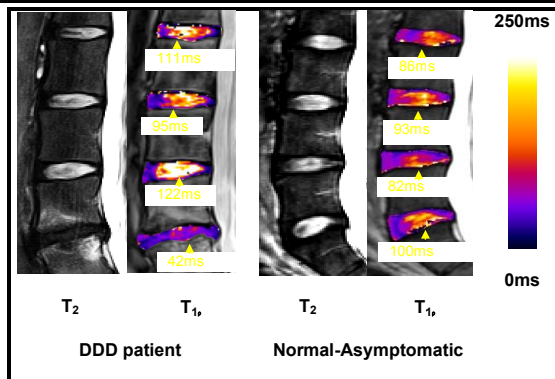
<sup>1</sup>CMROI, Department of Radiology, University of Pennsylvania School of Medicine, Philadelphia, PA, United States, <sup>2</sup>Department of Biochemistry & Molecular Biophysics, University of Pennsylvania School of Medicine, Philadelphia, PA, United States, <sup>3</sup>B Orthopaedics, Philadelphia, PA, United States, <sup>4</sup>Department of Bioengineering, University of Delaware, Wilmington, DE, United States

**OBJECTIVE:** To determine the sensitivity T<sub>1 $\rho$</sub>  and Pfirrmann grade in predicting painful discs that were subsequently surgical-treated in back pain patients.

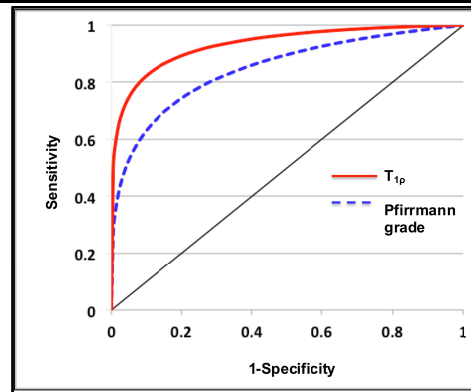
**BACKGROUND:** Diagnosis of degenerative disc disease (DDD), a common cause of low back pain (LBP), remains difficult, subjective, and controversial (1). Healthy discs rely on diffusion to transport nutrients and waste products between the surrounding blood vessels and the ordered collagen fibers of the annulus fibrosus (AF), to the central gel-like nucleus pulposus (NP). Age-related degradation is marked by a loss of the gel-like consistency of the NP including decreased proteoglycan content and decreased water concentration (2), while late-stage DDD is characterized by an NP indistinguishable from AF and a collapsed disc space. Due to the lack of a proper gold standard, the presence of pain in each disc is currently determined by provocative discography (3). The technique relies on the patients' subjective perception of pain as a needle is inserted into the disc. With limitations (4), imaging methods have relied on x-ray based methods to detect disc collapse and MRI-based Pfirrmann grading (5) method that relies on a semi-quantitative and subjective grading of the signal intensity on a mid-sagittal T<sub>2</sub> MRI. An alternative technique is T<sub>1 $\rho$</sub>  MRI, which has been demonstrated to correlate with NP proteoglycan content, and swelling pressure in cadaveric tissue and *in vivo* (6-9). In this study, we compare T<sub>1 $\rho$</sub>  measurements and Pfirrmann grading of patients' lumbar discs pre-surgery in order to determine the sensitivity of both methods in predicting painful discs (as measured by provocative discography) that eventually required surgery.

**METHODS:** All MRI scans were performed on a 3 Tesla Siemens Tim Trio clinical scanner (Siemens Medical, Malvern, PA) using the vendor-supplied spine array coil with approval from the Institutional Review Board and with subjects' consent. T<sub>1 $\rho$</sub>  and T<sub>2</sub> MRI were performed on patients a week prior to fusion surgery (n=12, 49 levels, mean age 44±6 years, range 30-53). Discography was performed with the placement of 22 gauge needles into the center of the L2/L3 through L5/S1 discs, using the IntelliSystem (Merit Medical) with digital pressure display, and the presence of pain at each level was ascertained. Following co-registration and segmentation procedures, average T<sub>1 $\rho$</sub>  (in milliseconds) was recorded from all lumbar discs using algorithms written in Matlab (Mathworks, Natick, MA). Pfirrmann grading was performed on T<sub>2</sub> MRI of the same discs by a single-reader with several years of experience in disc MRI analysis. Statistical descriptives and regressions were performed in SPSS Statistics 19.0 (IBM, Chicago, IL) to evaluate any relationships between T<sub>1 $\rho$</sub>  and Pfirrmann grade and painful discs that required surgery.

## RESULTS:



**Figure 1:** Examples of quantitative T<sub>1 $\rho$</sub>  maps (in color) corresponding to T<sub>2</sub>-weighted MRIs (grayscale) of a patient with DDD (A) and an asymptomatic normal volunteer (B). Average T<sub>1 $\rho$</sub>  values are indicated below each disc in ms and the L4-5 disc in A (T<sub>1 $\rho$</sub> =42ms) subsequently treated by 360-degree fusion.



**Figure 2:** Plot of ROC curve of T<sub>1 $\rho$</sub>  and Pfirrmann grade using a continuous rating scale of predictor of painful discs that subsequently underwent fusion surgery.

**CONCLUSIONS:** T<sub>1 $\rho$</sub>  MRI was more sensitive than Pfirrmann grading in detecting painful discs that required fusion surgery. T<sub>1 $\rho$</sub>  MRI shows a promising ability to detect painful discs and has the potential to measure patient outcomes from back surgery.

**SPONSORS:** This study was funded by AO Spine Research Grant and was performed at an NCRR-supported Biomedical Technology Research Center.

## REFERENCES:

- Adams M, Roughley P. What is intervertebral disc degeneration, and what causes it? *Spine* 2006;21(51):2161.
- Buckwalter JA. Aging and degeneration of the human intervertebral disc. *Spine* 1995;20(11):1307-1314.
- Tehranezhadeh J. Discography 2000. *Radiologic Clinics of North America* 1998;36(3):463-495.
- Sheehan NJ. Magnetic resonance imaging for low back pain: indications and limitations. *Ann Rheum Dis* 2010;69(1):7-11.
- Pfirrmann CW, et al. Magnetic resonance classification of lumbar intervertebral disc degeneration. *Spine* 2001;26(17):1873-1878.
- Johannessen W, et al. Assessment of human disc degeneration and proteoglycan content using T1rho-weighted magnetic resonance imaging. *Spine* 2006;31(11):1253-1257.
- Auerbach J, et al. In vivo quantification of human lumbar disc degeneration using T1rho-weighted magnetic resonance imaging. *Eur Spine J* 2006;15 Suppl 3:S338-344.
- Blumenkrantz G, et al. In vivo 3.0-tesla magnetic resonance T1rho and T2 relaxation mapping in subjects with intervertebral disc degeneration and clinical symptoms. *Magn Reson Med* 2010;63(5):1193-1200.
- Borthakur A, et al. T1 $\rho$  MRI and Discography Pressure as Novel Biomarkers for Disc Degeneration and Low Back Pain. *Spine* 2011.

Test Variables	ROC Area Under Curve	Asymptotic Sig. <sup>a</sup>	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
T <sub>1<math>\rho</math></sub>	.91	.001	.83	.99
Pfirrmann grade	.84	.001	.76	.93

**Table 1:** Results of ROC analyses.  
a. Null hypothesis: true area = 0.5