

T1ρ MRI and Discography Opening Pressure are Quantitative Biomarkers of Disc Degeneration In Vivo

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INTRODUCTION – A quantitative assessment of disc health is essential for selection of treatment options and to the future of biomedical research in the development of new spine technologies. The Pfirrmann grade determined from T2 MRI is currently the gold standard to determine disc degeneration [1]. This method has been valuable for research, yet is extremely limited as it is not a continuous quantitative measure. Alternatively, T1ρ-MRI has been evaluated in the nucleus pulposus (NP) and correlates with the Pfirrmann grade, glycosaminoglycan (GAG) content, and NP mechanical properties in cadaver spines [2,3] and human subjects [4]. Provocative discography is an invasive test frequently used to determine if degenerative disc pathology observed using standard imaging is responsible for lower back pain symptoms. While somewhat controversial due to the subjective nature requiring the patient's pain response, there are several quantitative pressure measurements obtained as part of a manometric-controlled study. Opening Pressure (OP), pressure where injected fluid first overcomes the internal osmotic pressure and enters the disc, is a potential indicator of degeneration. The objective of this study is to evaluate T1ρ MRI as quantitative biomarker of disc degeneration in patients being treated for lower back pain (LBP) by comparing it to discography OP.

METHODS – Patients being treated for LBP (n=13, 63 levels, avg age 45 years, range 35-53) and control subjects not being treated for back pain (CTL, n=9, 45 levels, avg age 43, range 22-76) were imaged. A subset of LBP patients receiving multi-level provocative discography followed by MRI were also evaluated (n=8, 26 levels, avg age 47, range 42-53). Studies were performed with IRB approval. MRI parameters and image processing techniques are described in Witschey et al. [5]. Discography data was obtained, following 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. Iohexol (Omnipaque 300), a low osmolar, nonionic, iodinated contrast agent was injected into each disc under continuous fluoroscopic imaging. The Opening Pressure (OP), when fluid first entered the NP, was recorded.

RESULTS

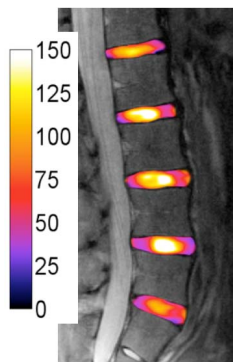


Fig. 1: T1ρ map (in color) of the lumbar discs overlaid on a T2 MRI (in grayscale from a normal subject).

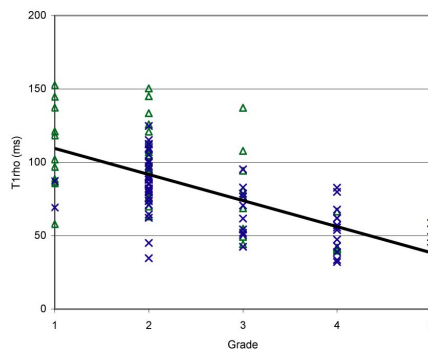


Fig. 2: T1ρ in the NP correlates significantly with Pfirrmann degenerative grade, ($r = -0.57$, $p < 0.005$, $n = 108$ levels for combined CTL (triangles) and LBP (x) subjects).

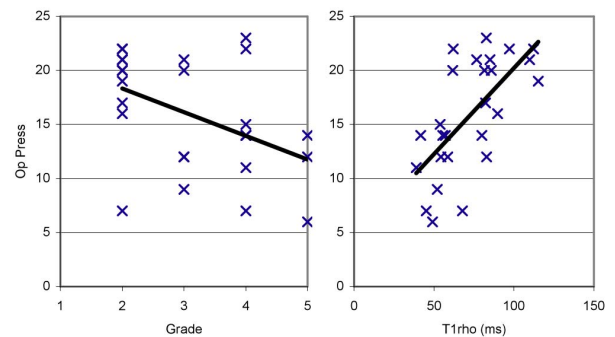


Fig. 3: Discography OP was significantly but moderately correlated with Pfirrmann grade (left, $p = 0.02$, $r = -0.45$, $n = 26$). However, correlation between OP and T1ρ time was significant and strong (right, $p < 0.0005$, $r = 0.66$, $n = 26$).

There are two primary findings of this study. First, we showed that T1ρ is a quantitative measure of degeneration that is consistent across both control subjects and LBP patients. A limitation of this correlation is the integer nature of the Pfirrmann grading scale; it is unlikely that better correlation could be achieved since this scale is not continuous. This application of T1ρ for quantifying degeneration is based only upon the NP region. Future studies will evaluate T1ρ in other disc regions to elucidate the mechanisms of disc degeneration. Second, we demonstrated a significant and strong correlation between the non-invasive T1ρ values and *in vivo* OP measurements obtained during discography. This is not surprising since T1ρ is related to NP GAG [2], which drives the disc osmotic pressure [7]. Thus, T1ρ appears to be quantifying disc health via the NP osmotic pressure. The OP is measured with the patient in the prone position, so reflects the NP pressure without axial loading. Since T1ρ and OP are both quantitative continuous measures, it would be expected that they would correlate better than either would correlate with Pfirrmann grade. While discography OP is a minimally invasive measure, T1ρ MRI has the advantage of being a non-invasive technique to determine NP GAG. The LBP patients in this study were a combination of surgical (fusion or disc arthroplasty) and non-surgical patients. These patients, and others still being recruited to the study, will be followed over the next several years to determine the change in NP T1ρ of adjacent non-operative levels and thus evaluate for potential progression of disc degeneration.

CONCLUSIONS – T1ρ is a quantitative measure of degeneration that is consistent across both control subjects and LBP patients. A significant and strong correlation exists between non-invasive MRI T1ρ values and *in vivo* OP measurements.

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REFERENCES [1] Pfirrmann+ Spine 26, 2001; [2] Johannessen+ Spine 31, 2006; [3] Nguyen+ JBJS 90, 2008; [4] Auerbach+ Eur Sp J 15, 2006; [5] Witschey+ J Mag Reson Imaging, 2008; [6] O'Connell+ Trans ORS 2009; [7] Ishihara+ Am J Physiol 272, 1997