Comparision of discography opening pressure to $T_{1\rho}$ relaxation in the inter-vertebral disc *in vivo*

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Background:

Lower back pain (LBP) is the second most frequent reason for a physician visit, permanently disables more than 5 million Americans and the annual costs are near $100 billion in the U.S. [1-4]. Conventional T_1 and T_2 MR imaging techniques are useful for observing late structural morphological changes to the intervertebral discs (IVDs) but are insensitive to early biochemical changes. These late structural changes are often clinically identified as late-stage degenerative disc disease [5]. However, early degeneration occurs within the nucleus pulposus (NP) in the IVD as large aggregating proteoglycans break down [6]. $T_{1\rho}$ MRI has the ability to detect these early biochemical changes within the IVD and studies have shown a correlation between disc degenerative grade using the qualitative Pfirrman scale and $T_{1\rho}$ MRI [7-9]. The purpose of our study is to determine the relationship between $T_{1\rho}$ and disc opening pressure acquired via invasive provocative discography.

Materials and Methods:

All experiments were performed with approval from the Institutional Review Board. MRI was performed on a Siemens clinical scanner with the vendor-supplied transmit/receive 8-channel spine array coil using a 3D $T_{1\rho}$ pulse sequence [10]. Imaging parameters: TE/TR/alpha = 3 ms/6ms/20°, acquisition matrix = 256x128x16, interpolated to 256x256x16, slab thickness = 80mm, in-plane resolution = 0.8x0.8 mm^2, T_1 Recovery Delay = 2 s, BW = 130Hz/pixel, centric k-space encoding, pulse train =128.

Five $T_{1\rho}$-weighted images were obtained (spin-lock duration 5,10,20,30,40 ms) to generate $T_{1\rho}$ relaxation maps. Images were fitted on a pixel by pixel analysis to the $T_{1\rho}$ exponentially decaying function. Mean disc and nucleus pulposus $T_{1\rho}$ relaxation rates were calculated using ROI analysis from maps generated from imaging the entire disc volume. Thirteen individuals were scanned using our $T_{1\rho}$ imaging procedure and clinical T_2-weighted images for Pfirrman grading. Five of these individuals had provocative discography performed and opening pressure values were obtained.

Results:

Figure 1 shows correlation between mean $T_{1\rho}$ values of the entire disc with opening pressure measurements from discography. Five individuals underwent discography where opening pressure values were recorded. Figure 2 confirms $T_{1\rho}$ values correlation with Pfirrman grade. Thirteen individuals were scanned to provide a large data set allow us to confirm previous findings that $T_{1\rho}$ values are linearly correlated with Pfirrman grade. Figure 3 shows representative subjects with $T_{1\rho}$ relaxation maps overlaid on an anatomical proton density image. Notice the large variation of the disc volume for the healthy individual (left) as compared to a homogeneous $T_{1\rho}$ distribution with severely degenerated discs (right).

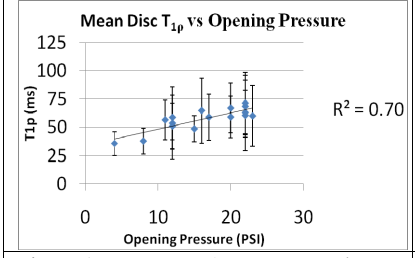

Figure 1 – Mean $T_{1\rho}$ (average over the entire disc) correlated with discography opening pressure measurments show a good correlation (R^2 of 0.70). Data is collected from five individuals with four discs measured per person.

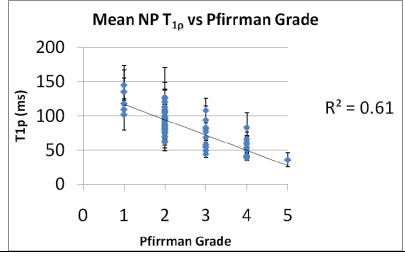

Figure 2 – Mean NP $T_{1\rho}$ measurments correlate with Pfirrman grade. Data is similar to findings found in literature. Data shown to act as a reference of our subjects to previous findings..

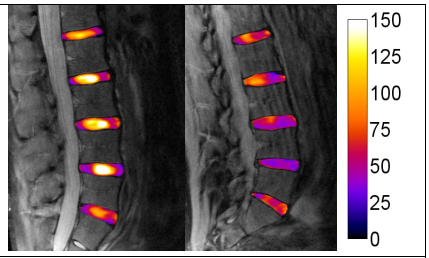

Figure 3 – $T_{1\rho}$ relaxation maps of the lumbar discs are overlaid on a proton density image. Healthy individual (20yo male) and a symptomatic individual with severe NP degeneration in L4-L5. Color-bar is $T_{1\rho}$ values in milliseconds.

Conclusions:

While preliminary, a moderate correlation has shown to exisit between discography opening pressure and $T_{1\rho}$ relaxation values. Initial results are promising in describing a relationship between *in vivo* MRI imaging and surgically invasive spine discography opening pressure. Correlation is higher between mean total disc $T_{1\rho}$ values as compared to NP values. While the variation of $T_{1\rho}$ values in respective ROIs vary substantially, it is shown that the mean standard deviation of all ROIs obtained decreases as you increase the homogeneity of the disc, corresponding to a higher Pfirrman grade.

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