INTRODUCTION:
Chronic low back pain is one of the most prevalent health complaints in the US, with an estimated 70-85% of the population developing back pain at some point in their life [1]. It is the leading cause of lost wages and accounts for more than 700,000 surgical procedures per year with a total over $50 billion annually spent on treatment and care [2,3]. Although the causes of low back pain are poorly defined and indistinct, the most often implicated tissue as the origin for pain is the intervertebral disc [4,5].

Traditionally, lumbar spine range of motion measurements and intervertebral disc gross morphology (based on MR images) are used to assess spinal health, but largely fail to correlate well with pain or provide clinically useful patient stratification [6,7,8]. These shortcomings may be due to a lack of individual spinal segment motion resolution and MR imaging techniques which do not provide quantitative data on the tissues. Quantitative T2 mapping uses MRI scanning sequences which evaluate T2 relaxation times and provide quantitative results. Specifically, T2* is a clinically viable methodology with a short acquisition time; this sequence has been beneficial in cartilage imaging [9]. The goal of this work is to link dynamic 3D kinematic data with advanced imaging of the intervertebral disc to develop a relationship between underlying disc morphology and functional motion.

METHODS:
Eighteen (11 male) osteoligamentous cadaveric lumbar spines (L3-Sacrum), acquired from the UofM Bequest Program, had an average age of 53.2±15.5 years (range: 21-71 years). Each specimen received a battery of imaging protocols and was exercised in the cardinal planes in the Spine Kinetic Simulator. All MR imaging was performed on a Siemens 3T unit (Magnetom Trio; Siemens Healthcare) equipped with a brain coil. Classic T2 weighted sagittal anatomic images were acquired for disc grading (Pfirrmann)[10]. T2* relaxation times [TR(ms): 500; TE(ms): 4.18, 11.32, 18.46, 25.60, 32.74, 39.88; Voxel Size(mm): 0.5x0.5x3.0; Slices: 31] were collected and quantitative T2* maps were constructed (MapIt, Siemens Healthcare). T2* map images were analyzed using Osirix Imaging Software across three equally spaced regions of interest (ROI) (Fig 1.). Within each ROI, the mean T2* values were recorded to assess the health of the disc.

RESULTS:
The Pfirrmann grades were the average of five experienced spine researchers and orthopedic surgeons; between observers variability was ± .89 grade. Intervertebral disc degeneration grade was found to be linearly related with the T2* continuous data (r = -0.8104; p < 0.0001).

Neutral zone (NZ) data (L3-S1) was correlated with the T2* data (r = -0.5917; p < 0.0097) compared with the categorical Pfirrmann grade data (r = 0.5391; p < 0.0210) (Fig 2). Likewise, the ratio of neutral zone to range of motion (NZ/ROM) was correlated to T2* data (r = -0.6302; p < 0.0051) compared with the categorical Pfirrmann grade data (r = 0.5747; p < 0.0126).

DISCUSSION:
The results demonstrate that the T2* MR imaging sequence data are correlated with the functional range of motion across motion segments of differential health. While Pfirrmann grade exhibits a correlation as well, the greater resolution of the continuous T2* data provides a stronger predictive value to disc biomechanical performance (NZ, NZ/ROM). It is likely that intersegmental kinematics will display similar correlations and will further the understanding between morphology and functional motion. The limitations of this study include the MR imaging of post mortem tissues with differential time to scan from death. Another limitation is the use of three discs within the same specimen where both grade and ROM are likely internally linked. In spite of these limitations, the T2* and kinematic outcomes appear to be good predictors of disc health.

SIGNIFICANCE:
This research aims to link dynamic 3D kinematic data with T2* imaging of intervertebral discs to uncover the mechanisms of disc degeneration. These data will improve diagnostic efficiency by coupling biochemical MRI imaging with function kinematic outcomes—altogether improving patient stratification and targeted therapeutic intervention for patients suffering from low back pain.

LITERATURE CITED:

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