Objective: To correlate intervertebral disc [Na\(^+\)] measured using sodium MRI in vivo at 7 T with degenerative grade

Introduction:
Sodium MRI has previously been validated as a technique for non-invasive [Na\(^+\)], [PG] and FCD quantification[1], using ex vivo bovine intervertebral disc (IVD) samples. However, sodium MRI’s role in the evaluation of IVD degeneration has yet to be quantitatively evaluated in an in vivo setting. In this study, we circumvented sodium MRI’s low SNR by conducting the experiment at a 7 T MRI scanner, and correlated the IVD [Na\(^+\)] value with degenerative grades of the IVDs. In addition, magnetization transfer (MT) MRI has been shown to be correlated with IVD collagen density[2]. Therefore, the IVD NP [Na\(^+\)] values calculated using sodium MRI in this study were also compared to magnetization transfer ratio (MTR) and T\(_1\)\(_p\) values, which were acquired separately on a 1.5 T MRI scanner. MTR, T\(_1\)\(_p\), and [Na\(^+\)] together may reveal a more detailed picture of the not yet completely understood mechanism of IVD degeneration.

Materials and Methods:
Three human volunteers (mean age = 42) were recruited for this study. After consent was obtained, the subjects were instructed to lay supine on a Siemens 7 T clinical MRI scanner (Erlangen, Germany). A custom-engineered single-loop surface RF coil (diameter = 22 cm) tuned to 7.06 MHz was inserted underneath the subject’s lumbar region. Sodium signal acquisition was carried out using a gradient echo (GRE) pulse sequence with the following sequence parameters: TR/TE = 320/8.77 ms, FOV = 400 x 400 mm, matrix = 128 x 64, slice thickness = 5 mm, number of slices = 32, NEX = 8, pulse duration = 2 ms, BW = 50 Hz/Pixel. The acquisition time was 24 minutes and 35 seconds. A single observer chose a 4 mm circular ROI in the center of each IVD NP. For each IVD, the NP [Na\(^+\)] value was computed by referencing it to the signal of the cerebro-spinal fluid of 150 mM [Na\(^+\)].

Conclusions:
This study successfully quantified IVD NP [Na\(^+\)] in vivo on a 7 T MRI scanner, and demonstrated in an in vivo setting that the IVD NP [Na\(^+\)] decreases with degeneration. The preliminary in vivo data on the cross correlation of MTR, T\(_1\)\(_p\), relaxation time constant and [Na\(^+\)] proved the clinical viability of these MRI techniques, which makes it possible to quantify a set of IVD tissue biomolecular properties such as [Na\(^+\)] and collagen content non-invasively in a longitudinal study.