Characterization of Intervertebral Disc Degeneration with T1ñ Imaging

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Introduction:

Degenerative disc disease (DDD) is the most common cause of back-related disability among North American adults. DDD translates into nearly 50 billion dollars in health-related expenditures in United States alone [1]. Conventional T_1 and T_2 imaging techniques are useful for observing morphological changes to the intervertebral disc (IVD). These structural changes are often identified as late-stage signs of DDD [2]. Earlier degenerative change occurs within IVD nucleus pulposus (NP), as large aggregating proteoglycans break down [3]. The $T_{1\rho}$ relaxation time during a spin-locking pulse has enhanced sensitivity to the interaction between bulk water molecules and extracellular matrix macromolecules [4], such as the proteoglycans in the NP. In this study, we used $T_{1\rho}$ imaging to characterize normal age-related IVD degeneration. Ultimately, $T_{1\rho}$ weighted imaging may provide clinicians with a method to conduct non-invasive evaluation of IVD degeneration.

Materials and Methods:

MR imaging was performed on nine human cadaver spine specimens (mean age: 45 years, range: 22~66 years) on a Siemens Sonata 1.5 T clinical scanner with the vendor-supplied 8-channel spine array coil. Sagittal T_1-weighted images of the spines were obtained as references for subsequent $T_{1\rho}$ maps. A series of $T_{1\rho}$ images were obtained using a spin-lock prepared spin-echo pulse sequence [5] with the following parameters: TE/TR=12/3000ms, TSL (duration of spin-lock pulse)= 15, 30, 45, 60 and 75 ms, slice thickness=5mm, FOV=30x13cm, Matrix=512x224 for a total imaging time of 28 minutes for five images. $T_{1\rho}$ values were calculated by applying linear-regression on a pixel-by-pixel basis in all five images to the exponentially decaying function: $S(t_{TSL}) = S_0 e^{-(t_{TSL}/T_{1\rho})}$ [4]. Afterwards, a region of interest was selected in the L2/L3 IVD NP by a single observer. Each IVD NP's mean $T_{1\rho}$ and standard deviation were obtained using ImageJ software.

Results and Discussion:

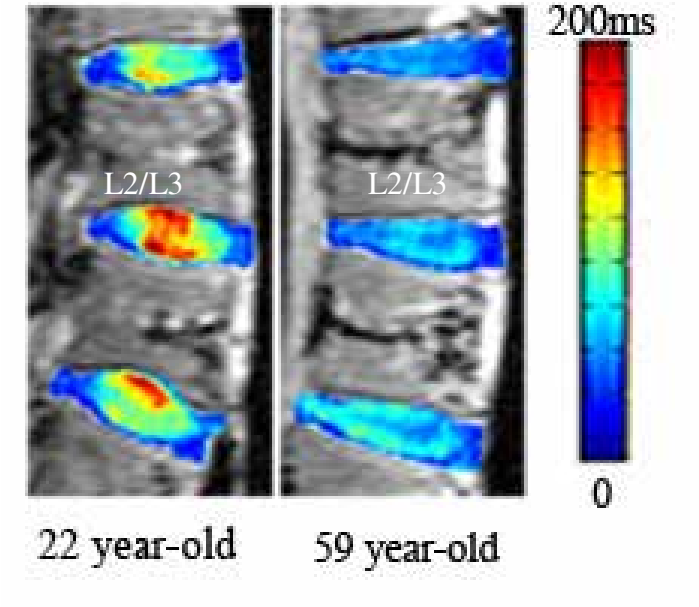

Figure 1

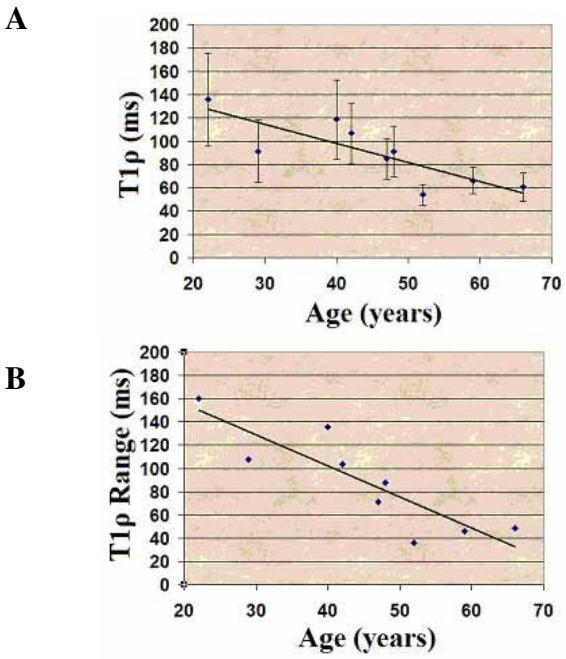

Figure 2

Figure 1 shows a color $T_{1\rho}$ map overlaid on a T1-weighted image (grayscale) of the lumbar region from a 22 year-old and a 59 year-old human cadaver spine. Each IVD is composed of two parts: the centrally-located NP surrounded by a ring-shaped annulus fibrosis (AF). In the $T_{1\rho}$ map, the AF shows up as the dark blue region (low $T_{1\rho}$ values); the lighter colored (high $T_{1\rho}$ values) region is the NP. Figure 2A plots average $T_{1\rho}$ value of the NP region for each L2/L3 IVD against its specimen's age. The standard deviation of all $T_{1\rho}$ values within each NP region was graphed as the error bar. A linear fit of the data points yielded a correlation coefficient of 0.82, which suggests a strong relationship between $T_{1\rho}$ of NP and the specimen's age. In the course of the study, we also noted that the distribution of $T_{1\rho}$ values within each NP varied between across age. The lower graph in Figure B plots the range of $T_{1\rho}$ in the L2/L3 NP versus its specimen's age. Range is defined here as two standard deviations above and below the mean, which eliminated some outlier $T_{1\rho}$ values. The linear fit of this data yielded a high correlation coefficient of 0.87. In conclusion, our study has found that both the average and the range of $T_{1\rho}$ values in IVD NP decrease with age, and this trend may be linear. In the near future, we intend to expand our study to include *in vivo* $T_{1\rho}$ imaging of human IVD and to construct a robust IVD degeneration-grading scheme based on its $T_{1\rho}$ values.

Acknowledgements:

This work was performed with grant support from NIAMS and NCRR.

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