In Vivo Assessment of Human Lumbar Disc Degeneration

A. Borthakur[1], J. D. Auerbach[2], W. Johannessen[2], C. A. Dolinskas[3], R. A. Balderston[4], D. M. Elliott[2], R. Reddy[1]

[1]MMRRCC, Department of Radiology, University of Pennsylvania, Philadelphia, PA, United States, [2]Department of Orthopaedic Surgery, University of Pennsylvania, Philadelphia, PA, United States, [3]Department of Radiology, Pennsylvania Hospital, Philadelphia, PA, United States, [4]Booth, Bartolozzi, and Balderston Orthopaedics, Pennsylvania Hospital, Philadelphia, PA, United States

Introduction

As emerging treatment technologies such as total disc arthroplasty, cell therapy, growth factor therapy and nucleus replacement are developed to supplant lumbar spine fusion in treatment of low back pain, there is an increasing demand for objective measurements of early disc degeneration (1, 2). Spin-lock $T_{1\rho}$-weighted MRI was recently shown to provide a quantitative, objective, and non-invasive assessment of disc degeneration in cadaveric human spine specimens (3). The goal of the present study was to assess the feasibility of using $T_{1\rho}$ MRI to detect intervertebral disc degeneration *in vivo*.

Materials and Methods

The Institutional Review Board (IRB) of our institute provided consent to subject ten subjects (5 males, 5 females) to $T_{1\rho}$ and T_2 MRI of their lumbar spine. We included those between the age of 40-60 with no prior back surgery and no significant back pain within the past 6 months (as determined by absence from work due to back pain, a period of bracing, or diagnostic/therapeutic injections). Each volunteer was imaged on a 1.5T Siemens Sonata clinical whole-body MRI scanner according to two protocols. First, a conventional T_2-weighted image was acquired using a standard spin-echo imaging sequence to assess disc degenerative grade (n=50 discs) according to the classification system described by Pfirmann et al (4). Imaging parameters were: TE/TR = 127ms/4300ms, FOV = 28cm x 28cm, slice thickness = 4mm and acquisition matrix = 256 x 256. Secondly, a series of images $T_{1\rho}$-weighted images were acquired using a turbo spin-echo based $T_{1\rho}$ MRI sequence (5) with the same imaging parameters as the T_2-weighted images but with minimum TE (12ms) and varying the spin-lock pulse duration. Spin-lock pulse durations ranged from 15 to 75 ms with a spin-lock amplitude set to correspond to a B_1 of 400 Hz. Two experienced clinicians determined the degenerative grade of each lumbar disc and their average grade was recorded. A spatial map of $T_{1\rho}$ was generated by linear regression of pixel intensity data to an exponential decay function and a 5mm circular region of interest (ROI) was manually selected in the center of the nucleus pulposus in order to calculate mean $T_{1\rho}$ (Figure 1, $T_{1\rho}$ map) by two investigators independently.

Results and Discussion

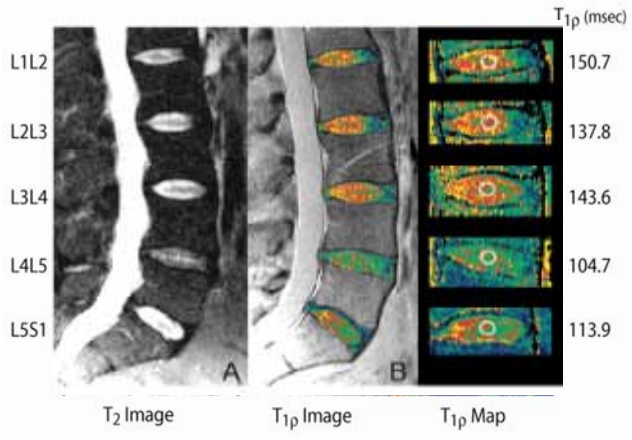

Figure 1

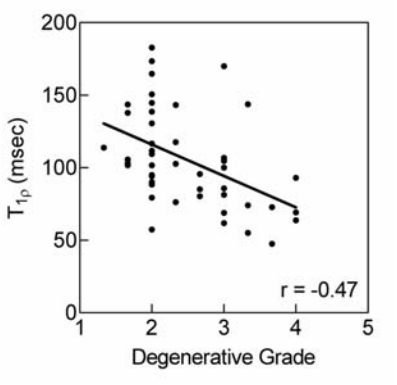

Figure 2

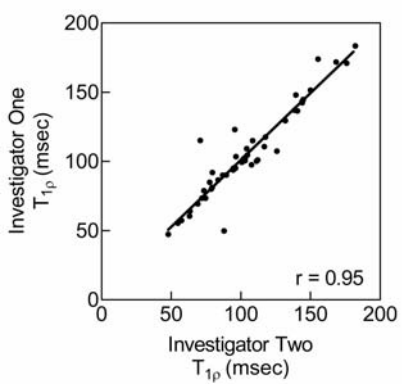

Figure 3

A typical set of images is shown in Figure 1. This one is from an asymptomatic 41-year old male subject. Notice the slight loss of signal intensity on the T_2-weighted image suggesting degeneration in the L4-L5 disc. A lower $T_{1\rho}$ relaxation time (~105 ms) was observed in the same disc on $T_{1\rho}$ map (color map) that was overlaid on the $T_{1\rho}$ weighted image (grayscale). In the enlarged views of the $T_{1\rho}$ maps, the regions of interest where average $T_{1\rho}$ values were measured are indicated with the white circle. Figure 2 plots the relationship between $T_{1\rho}$ and degenerative grade in all 50 discs samples used in the present study. An inverse relation between $T_{1\rho}$ and degenerative grade was observed. Two independent investigators selected ROIs to calculate mean $T_{1\rho}$ from within center of the nucleus pulposus and as Figure 3 indicates, they were in excellent agreement (r=0.95).

Acknowledgements:

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