MR spectroscopy in intervertebral disc -- a feasibility study

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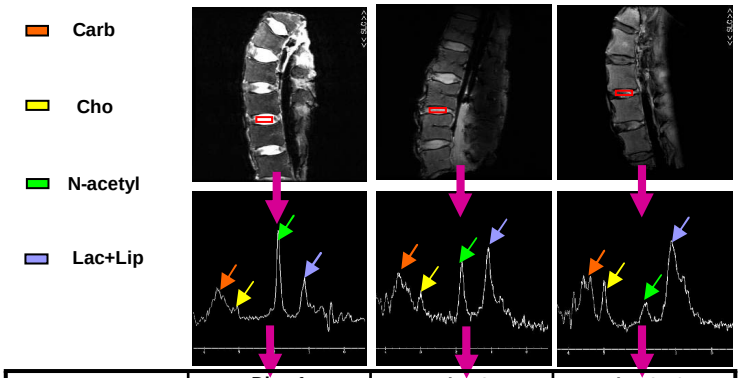
Introduction Great efforts have been put on studying lower back pain related intervertebral disc disease (IVDD). However, most previous studies depend on developing morphologic criteria for classification and grading disc degeneration. Because of image interpretation subjectivity and interobserver variability, it is necessary to develop techniques to quantify disc degeneration that will facilitate the study of disease progression. Intervertebral disc degeneration usually begins with biochemical changes within the disc. Therefore, quantifying the concentration of the metabolites in the discs would provide important information that is associated with disc degeneration. Previously, high-resolution magic-angle spinning (HR-MAS) spectroscopy has been used to correlate *in vitro* disc degeneration with the changes of concentration of the metabolites in disc [1]. In this study, we demonstrate the feasibility of using non-invasive MR spectroscopy to estimate the concentration of metabolites in cadaveric disc and correlate the peak height ratios of the metabolite with the Pfirrmann grading scheme [2]. In addition, a preliminary *in vivo* human study was conducted.

Method A total of 10 cadaveric human lumbar intervertebral discs (ages 46-79) were harvested and freshly frozen. The discs were then imaged on a 3 Tesla GE Excite Signa whole body MR scanner (General Electric Medical Systems, WI) using a GE 8 channel phase array knee coil. The image protocol was composed of a T2 weighted fast spin echo (FSE) sequence (for Pfirrmann grading) and a single voxel spectroscopy (SVS) sequence. The MR spectroscopy sequence was a point-resolved spectroscopy (PRESS) sequence with a three-pulse chemical shift selective (CHESS) saturation sequence for water suppression (TE/TR = 35/2000 msec, 1024 data points, 256 repetitions, total imaging time 9 mins). For *in vivo* human study, same imaging protocol was used with a GE 6 channel spine coil. This study was approved by our Institutional Review Board. The data acquired from multiple channels of the coil were combined and the ratios of spectroscopic peak height of different metabolites were calculated using previously developed method [3]. Pfirrmann grading was performed by an experienced radiologist. The correlation between the peak ratios and the Pfirrmann grades was evaluated with Pearson correlation coefficient.

Results One Pfirrmann grade 1, one Pfirrmann grade 2 and 8 Pfirrmann grade 3 discs were specified of the 10 studied discs. Based upon previous literature [1], 4 spectral regions were identified in each acquired spectrum: the carbohydrate (Carb) region (3.50-4.20ppm) associated with collagen break down, the choline head group (Cho) (3.15-3.30ppm), the N-acetyl region (N-acetyl) (1.90-2.10ppm) associated with proteoglycans (PG) and the lipid and lactate region (Lac+Lip) (1.15-1.40ppm). Three peak height ratios (N-acetyl/Carb, N-acetyl/Cho, Cho/Carb) were calculated. Representative T2-weighted images, spectrum and the corresponding peak height ratios are shown in Fig. 1. The N-acetyl/Carb ratio and the N-acetyle/Cho ratio increase as the Pfirrmann grade increase, while the Cho/Carb ratio decrease with the Pfirrmann score. The changes of the latter two ratios agree with previous study [1]. Strong correlations were found between the Pfirrmann score and the N-acetyl/Carb (Pearson correlation coefficient r = -0.98) and N-acetyle/Cho (Pearson correlation coefficient r = -0.97). Figure 2 depicts the *in vivo* human disc study results, showing spectra from two discs, one assessed as Pfirrmann grade 2 (Fig. 2b) and one assessed as Pfirrmann grade 3 (Fig. 2c). The N-acetyle/Cho ratio changed from 6.41 for the Pfirrmann grade 2 disc to 3.61 for the Pfirrmann grade 3 disc, and the Cho/Carb ratio changed from 0.30 to 0.64. This trend agreed with previous study as well.



	Disc 1	Disc 2	Disc 3-10
Pfirrman Grade	1	2	3
N-acetyl/Carb	2.92	1.27	0.38±0.14
N-acetyl/Cho*	9.79	2.96	0.70±0.17
Cho/Carb*	0.30	0.43	0.55±0.14

Fig. 1. Representative T2-weighted images, spectrum and the computed peak height Ratios for different Pfirrmann grade discs , *indicates the results agree with previous study [1].

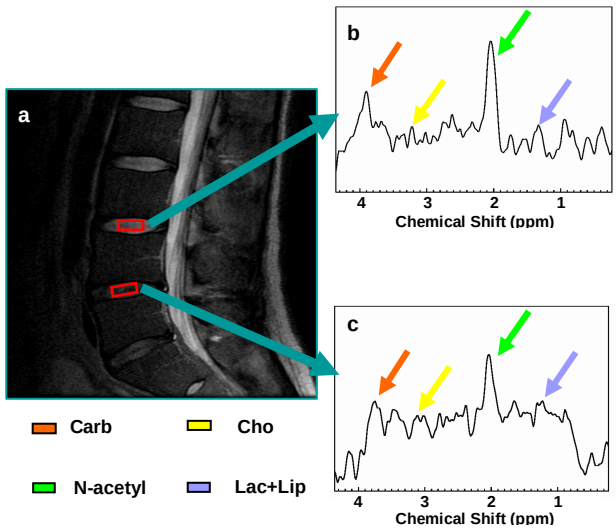


Fig.2. Two discs (assessed as Pfirrmann grade 2 and 3 respectively) were selected from the T2-weighted image (**a**), the corresponding spectrum are shown in (**b**) and (**c**).

Discussion Using quantitative MR spectroscopy method for IVDD detection *in vivo* has remained a challenge due to the low signal-to-noise ratio, the presence of lipid in adjoining bone marrow and bone susceptibility induced line broadening [4]. This study results indicated that it is feasible to applying SVS to detect the metabolite ratio changes in the intervertebral disc using our technique. The change of metabolite ratios in the discs correlated with Pfirrmann grades. The results concurred with the literature. The current study was limited by available discs (only 1 Pfirrman grade 1 disc and 1 Pfirrman grade 2 disc were studied). More cadaveric discs with different Pfirrman scores are needed to test the significance of these metabolite ratio changes. The *in vivo* human scan showed the spectrum of two discs with different Pfirrmann grades. Because of the reasons mentioned earlier, the SNR of *in vivo* scan was much lower compared to the cadaveric disc scans. Nevertheless, the quantification results demonstrated the same trend of the metabolite ratio changes as the cadaveric disc study and the literature. With further coil and sequence development, more *in vivo* human scans, SVS might offer great potential for *in vivo* quantitative disc degeneration study.

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