

Quantitative Assessment of Normal and Degenerative Intervertebral Discs Using Apparent Diffusion Coefficient with GRAPPA

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Introduction

Diffusion-weighted imaging (DWI) is a new method to quantitatively image intravoxel incoherent motion *in vivo*; it is widely used in grading the cellularity of tumors; and its clinical usefulness has been established using the apparent diffusion coefficient (ADC) [1-2]. Though DWI was introduced to evaluate the spinal cord, there is little of use of magnetic resonance imaging (MRI) in the lumbar intervertebral disc [3-4].

The purpose of our study is to determine if a significant difference between disc ADC and MR findings of disc degeneration.

Materials and Methods

Sixty-two consecutive subjects (36 male and 26 female patients; aged 24 to 80 years, mean 55.4) were studied with 1.5-Tesla MRI units (Magnetom Quantum and Sonata, Siemens, Germany) with a phased-array spine coil for benign diseases—back pain or sciatica—or suspected spinal cord disease. Inclusion criteria were no history of malignant, hematologic, or systemic disease. In addition to the routine sequences, such as T₁-weighted image and T2-weighted image sagittal images, DWIs were obtained with spin-echo sequences with GRAPPA, a parallel imaging technique, (acceleration factor = 2) and the following parameters: repetition time (TR) = 1000; echo time (TE) = 38; field of vision (FOV) = 280 × 280 mm, thickness = 5mm; and b values = 0, 400, and 800 sec/mm² (Fig. 1). The reconstructed voxel size was 2.2 × 2.2 × 5.0 mm. The extent of degeneration in the L3-L4 intervertebral disc was graded on the sagittal images of T2-weighted image according to the criteria used by Weishaupt et al. [5]. Grade 1 was normal, and grade 5 was grouped as most severe degeneration [5]. We established two groups, a normal disc group (grade 1 and grade 2) and a degeneration disc group (grade 3, grade 4 and grade 5).

The ADC was measured from regression using three b-values in L3-4 disc with software of the employed MRI system. The region of interest was measured the central portion of the L3 -L4. Medean and standard error (SE) were calculated for the ADC. The medians of ADC were compared using Mann-Whitney's U test and commercially available software (JMP; SAS Institute Inc.). Significance was defined as *P* < 0.01.

Results

The ADC values of the L3-L4 intervertebral disc for each group were (median+/-SE): normal disc group: (1.69 +/- 0.04×10⁻³ mm²/sec) and degenerative disc group: (1.20 +/- 0.04 ×10⁻³ mm²/sec) (Figs. 1, 2, and 3). The median ADC values of normal disc group was significantly higher than that of degenerative disc group (*P* < 0.01).

Discussion and Conclusion

The ADC values of normal disc group were high and of degenerative disc group, low. Kealey SM and colleagues reported respective ADC values degeneration disc and normal disc marrow of 2.27 × 10⁻³ mm²/second and 2.06 × 10⁻³ mm²/second [3]. These ADC values are higher than those of our normal and degenerative disc, probably because the b values chosen in our study and in prior studies were differences (0, 400 and 800 sec/mm² in our study compared with 0, and 400 sec/mm² in the previous studies).

Tissue ADC is thought to be composed of extra- and intracellular tissue compartments [3,4]. Disc degeneration is characterized by a loss of extracellular water in the nucleus pulposus and disc ADC value is decreased. In conclusion, a statistically significant decreased in the ADC values of degenerated lumbar disc compared with the ADC values of normal disc.

References

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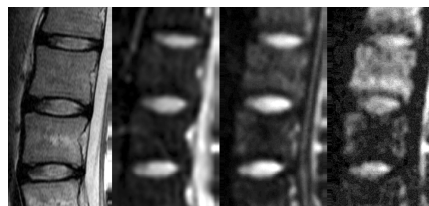


Fig. 1 (a) (b) (c) (d)
A 29-year old male of normal disc ADC=1.76×10⁻³ mm²/second (a) T2WI (b) DWI (b value=0) (c) DWI (b value=400) (d) DWI (b value=800)

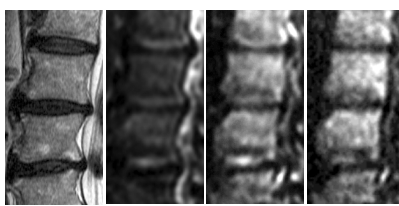


Fig. 2 (a) (b) (c) (d)
A 75-year old male of degenerative disc. ADC=1.05×10⁻³ mm²/second (a) T2WI (b) DWI (b value=0) (c) DWI (b value=400) (d) DWI (b value=800)

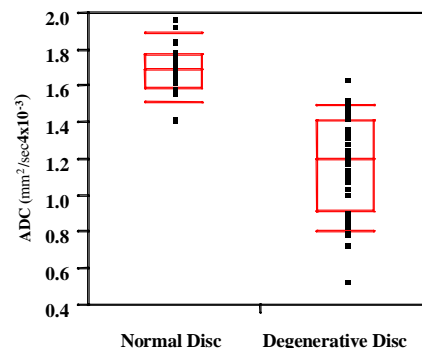


Fig. 3 ADCs of intervertebral disc