Quantitative Assessment of Compression Fracture Using Apparent Diffusion Coefficient with GRAPPA: Acute, Chronic, and Pathological Compression Fractures

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Introduction

Diffusion-weighted images are widely used in the early detection of cerebral infarction, and their clinical usefulness has been established. In addition, the apparent diffusion coefficient (ADC) has been reported useful in the qualitative diagnosis of tumors and changes that occur as a result of treatment [1-2]. Magnetic resonance imaging (MRI) is well accepted as a means to detect bone metastasis and vertebral compression fracture. However, even with MRI, determining the cause of compression fractures remains problematic [3-4].

We combined spin-echo echo planar imaging (EPI)-DWI with GRAPPA, a parallel imaging technique, to assess whether we could differentiate compression fractures in the chronic and acute phases without malignancy and compression fractures caused by malignant tumor.

Materials and Methods

We studied 39 patients (23 men, 16 women; aged 24 to 87 years [mean, 65.8]) using 1.5-T MRI units(Magnetom Sonata and Quantum; Siemens, Germany) with phased-array spine coil. In addition to the routine sequences, such as T_1-weighted, T_2-weighted, and fast short tau inversion recovery (STIR), all patients with compression fractures underwent spin-echo DWI in EPI taken in sagittal sections using GRAPPA with an accelerator factor of 2. The b factors used for DWI were 0, 400, and 800 sec/mm^2. Other imaging parameters were repetition time (TR) =1000; echo time (TE) =38; field of vision (FOV) = 280 × 280 mm; matrix size = 256 × 240; thickness = 5 mm; and slice gap = 1 mm. Averaging was done twice, and the reconstructed voxel size was 2.2 × 2.2 × 5.0 mm. The diffusion gradient was applied along 3 axes.

The patients were divided into three groups. Group 1 comprised 16 patients with 17 compression fractures that had occurred more than one month before MRI; Group 2, 10 patients with 10 acute compression fractures, defined as fractures occurring within a month of examination; and Group 3, 13 patients with 15 neoplastic compression fractures of the vertebral body and who had known metastatic malignancy. An ADC map was created with software provided with the MRI scanner, and ADCs were determined by measuring the signal intensity with the map. Means and standard deviations (SD) were calculated for ADC of each group, and means of ADC were compared by Tukey-Kramer test using commercially available software (JMP; SAS Institute Inc.). Significance was defined at $P < 0.01$.

Results

The mean ADC and SD were: for Group 1, 74 ± 11 × 10^{-5} sec/mm^2; for Group 2, 123 ± 21 × 10^{-5} sec/mm^2; and for Group 3, 96 ± 14 × 10^{-5} sec/mm^2. Quantitative distribution of data via MRI is shown in Fig. 2. These groups displayed a significant difference in individual Tukey-Kramer test results, with a 1% significance level.

Discussion and Conclusion

A compression fracture in the acute phase displays a higher ADC than one caused by a malignant tumor because the malignancy decreases cortex and trabeculae and increases extracellular space. With a compression fracture in the acute phase, extracellular space is greater because of trabecular changes from the fracture and ADC is greater. However, edema occurring in a compression fracture in the acute phase comprises more free water protons than does the edema occurring in the presence of tumor cells. The ADC of a compression fracture in the acute phase is higher than that caused by a malignant tumor.

This technique has the potential to aid in discriminating between neoplastic and non-neoplastic compression fractures. Furthermore, it allows discrimination between acute non-neoplastic fractures and chronic compression fractures.

References

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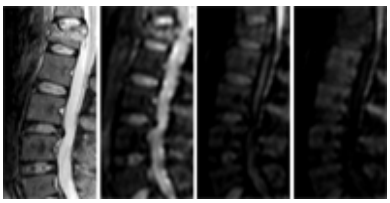

Fig. 1 (a) (b) (c) (d)
A 38-year old female of acute Fx. (Group 1): ADC=2.25x10^{-3} (a)STIR (b) DWI(b factor=0)(c) DWI (b factor=400) (d) DWI (b factor=800)

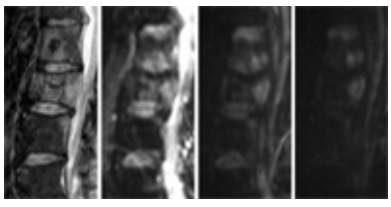

Fig. 2 (a) (b) (c) (d)
A 52-year old male of pathological Fx. (Group 3): ADC=1.25x10^{-3} (a) STIR (b) DWI (b factor=0) (c) DWI (b factor=400) (d) DWI (b factor=800)

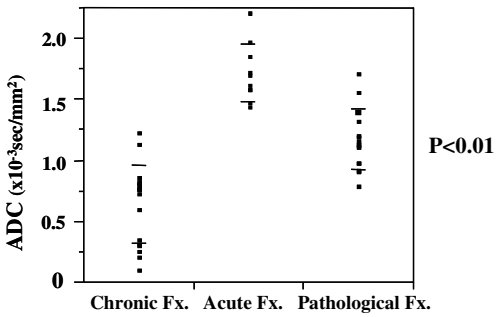

Fig. 3 ADCs of Compression Fractures