

Quantitative Diffusion and Fat Imaging of Vertebral Compression Fractures

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Introduction

Correct determination of the nature of a vertebral compression fracture (VCF) can directly impact patient management. However, both metastases and benign processes (such as osteoporosis) can lead to VCFs. Preliminary studies indicate that diffusion weighted imaging (DWI) can help with VCF characterization [1]. Another method that has been found useful is fat/water in-phase (IP) and opposed-phase (OP) imaging [2,3]. In this research we measured, in the same imaging sessions, the apparent diffusion coefficient (ADC) and the relative fat content of VCFs in cancer patients. Our objective is to determine the value of the ADC and the relative fat content in characterizing the true etiology of VCFs.

Methods and Materials

All imaging data were collected on a 1.5T clinical scanner (GE Healthcare, Milwaukee, WI) using a CTL spine phased array coil (USA Instruments, Ohio). A total of 14 cancer patients (mean age = 61 years, range = 36 to 76 years) with VCFs were enrolled into the study. In addition to the routine images from sagittal T2-weighted and T1-weighted imaging (pre- and post-contrast agent injection), we acquired sagittal diffusion weighted images ($b = 0$ and 300 s/mm^2) with a non-CPMG fast spin echo based pulse sequence [4] with the following scan parameters: TR/TE= 5000/89 ms, receiver bandwidth= $\pm 125 \text{ kHz}$, acquisition matrix= 128×128 , 8 signal averages, FOV= 32 cm, slice thickness/gap= 6/1 mm, total imaging time= 3:23 minutes. Within the same imaging sessions, we also acquired separate water-only and fat-only images using a spin echo based two-point Dixon technique [4] with the following parameters: TR/TE= 300/12 ms, receiver bandwidth= $\pm 20.83 \text{ kHz}$, acquisition matrix= 256×256 , 1 signal average, FOV= 32 cm, slice thickness/gap= 6/1 mm, total imaging time= 2:42 minutes.

Following image acquisition, ADC maps were generated using Functool software (GE Healthcare Technologies, Waukesha, WI). With guidance from routine T2-weighted and T1-weighted images and help from radiologists, regions-of-interest (ROIs) were selected within the VCFs on the ADC maps, as well as on the water-only and fat-only images. The ADC values and the values for fat content (defined as $(\text{Fat Signal})/(\text{Fat Signal} + \text{Water Signal})$) were recorded for each VCF. The diagnostic reference, indicating whether a VCF is malignant or benign, was established by radiologists based on the review of routine images, clinical history and follow-up. Two separate student's t-tests were performed to determine if significant differences exist between the mean ADC and fat content of benign and malignant VCFs.

Results

Fig. 1 presents the ADC histogram for a total of 35 VCFs (19 benign and 16 malignant) identified in all patients. The mean ADC values and standard deviations for benign and malignant VCFs were $(0.0015 \pm 0.0005 \text{ mm}^2/\text{s})$ and $(0.0008 \pm 0.0005 \text{ mm}^2/\text{s})$, respectively. A student's t-test revealed a significant difference ($p < 0.005$) between the mean ADC values of benign and malignant VCFs. A representative case with a malignant VCF and another case with a benign VCF are illustrated in Fig. 2 and Fig. 3, respectively. Fig. 2a, b, and c) show respectively, the T1-weighted pre-contrast, T1-weighted post-contrast, and ADC map for a patient with metastatic breast carcinoma. Although the lesion (located at T11) does not show contrast enhancement, the ADC measurement over the ROI (indicated by the circle) yields a value of $0.0008 \text{ mm}^2/\text{s}$. In comparison, Fig. 3a, b, and c) are the T1-weighted pre-contrast, T1-weighted post-contrast, and ADC map images, respectively, for a patient with metastatic carcinoma of the colon. The vertebral collapse (located at L1) was diagnosed as osteoporotic, but shows significant enhancement after contrast agent injection on T1-weighted images. The ADC value from the ROI was found to be $0.0014 \text{ mm}^2/\text{s}$.

The mean fat content values and standard deviations of the benign and malignant VCFs from all patients were found to be (0.26 ± 0.22) and (0.21 ± 0.20) , respectively. Contrary to the findings by some previous investigators [2,3], the student's t-test revealed that for our patient population, no significant difference existed within the 95% confidence level between the mean fat content values of the benign and malignant VCFs.

Conclusions

In summary, we performed quantitative diffusion and fat content measurements on a total of 14 cancer patients. In 35 identified VCFs, our results show that the quantitative ADC values are significantly different for benign and malignant VCFs and therefore maybe useful for their differentiation. In contrast, no significant difference was found between the fat content values of the benign and malignant VCFs.

References

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