Differential diagnosis of vertebral compression fracture using in-phase/opposed-phase and Short TI inversion recovery imaging

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Purpose

The aim of this study was to evaluate the usefulness of in-phase/opposed-phase short TI inversion recovery (STIR) magnetic resonance imaging (MRI) of bone marrow for differentiation between benign and malignant vertebral compression fractures.

Methods and Materials

A total of 70 compression spine fractures or vertebral lesions in 66 patients were retrospectively reviewed. The study population consisted of 36 men and 30 women ranging age from 38 to 87 years old. Thirty-nine of these lesions were in the lumbar spine, 28 in the thoracic spine, and 3 in the cervical spine. MR imaging was performed with a 1.5-T system (Achieva Intera; Philips Medical Systems, Best, The Netherlands) with a spine-array surface coil. Sagittal T1-weighted spin-echo (TR/TE= 459/15), T2-weighted spin-echo (TR/TE = 3000/85), short tau inversion recovery (STIR) (TR/TE/TI = 3500/85/160), and in-phase/opposed-phase imaging: double echo-gradient echo (TR/TE/FA = 180, 2.3/4.6, 75) with a section thickness of 4 mm were performed in all patients. Ethical review board approval was obtained for this analysis, and all patients gave their informed consent.

SIRs(in/opposed) were calculated from average signal intensity of the ROIs of in-phase images and opposed-phase images for 70 compression fractures. Signal intensity values were measured in operator-defined ROIs over the compression fracture area using a cursor and graphical display device. These areas were identified on the in-phase/opposed-phase images referring to the T1 and T2 weighted images (Figure 1). The ROI positions of in-phase and opposed-phase images were the same in all images.

Furthermore, SIRs(STIR) were calculated from average signal intensity of the compression fracture location and the adjacent normal bone marrow.

Signal intensity values were measured in operator-defined ROIs over the abnormal signal area and closed normal signal area using a cursor and graphical display device (Figure 2).

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SIR(STIR) = \frac{SI \text{ of compression fracture bone}}{SI \text{ of normal bone}}
\]

Diagnosis was confirmed by biopsy (24 lesions) or follow-up MRI performed 6 - 10 months later (49 lesions). The follow-up criteria in which the resolution of the bone marrow edema was considered benign for diagnosis were as described by Mouloupoulos et al. (13). Nine patients with 10 fractures had a definite traumatic history where the interval
between the accident and MRI examination was 5 days. The malignant group consisted of 24 patients with 27 vertebral fractures. The primary neoplasms included breast carcinoma \((n = 9)\), prostate carcinoma \((n = 8)\), gastric carcinoma \((n = 4)\), multiple myeloma \((n = 1)\), and malignant lymphoma \((n = 2)\).

The relationships between values of SIRs\((\text{in/opposed})\) and SIRs\((\text{STIR})\) and the differential diagnosis of malignant vs. benign status were examined.

**Images for this section:**

![Setting of the ROI for calculation of SIR(opposed/in).](image)

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\text{SIR(opposed/in)} = \frac{\text{SI of opposed-phase image}}{\text{in-phase image}}
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**Fig. 1:** Setting of the ROI for calculation of SIR(opposed/in). Signal intensity values were measured in operator-defined ROIs over the compression fracture area using a cursor and graphical display device. These areas were identified on the in-phase/opposed-phase images referring to the T1 and T2 weighted images. The ROI positions of in-phase and opposed-phase images were the same in all cases.
Fig. 2: Setting of ROIs for calculation of SIR (STIR). SIRs(STIR) were calculated from average signal intensity of the compression fracture location and the adjacent normal bone marrow. Signal intensity values were measured in operator-defined ROIs over the abnormal signal area and closed normal signal area using a cursor and graphical display device.

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\text{SIR(STIR)} = \frac{\text{SI of compression fracture bone}}{\text{SI of normal bone}}
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Results

The results of SIRs(opposed/in) for 73 compression fractures are shown in Figure 3. The bone marrow was benign in all cases in which SIR(in/opposed) was less than 1.0. However, when SIR(opposed/in) was more than 1.0, the compression fractures showed malignancy in many cases, but benign marrow was observed in nine cases.

The SIRs(STIR) for 73 compression fracture STIR images are shown in Figure 4. When SIR(STIR) was greater than 2.0, bone marrow was benign in all cases; all of these were cases of acute compression fracture disease.

In addition, Figure 5 shows the relations of SIRs(opposed/in) and SIRs(STIR) for benign, malignant, and acute benign fracture.

Benign chronic compression fractures had SIR(opposed/in) less than 1.0, and benign acute compression fractures had SIR(opposed/in) greater than 1.0 but SIR(STIR) greater than 2.0.

Images for this section:
Fig. 3: SIRs(opposed/in) for 73 compression fractures. Bone marrow was benign in all cases in which SIR(in/opposed) was less than 1.0. However, when SIR(in/opposed) was more than 1.0, compression fractures were malignant in many cases, but nine cases of benign marrow were included.
**Fig. 4:** SIRs(STIR) for 73 compression fracture STIR images. Bone marrow was benign in all cases in which SIR(STIR) was greater than 2.0.
**Fig. 5:** Relations of SIRs(opposed/in) and SIRs(STIR) for benign, malignant, and acute benign fracture. Benign chronic compression fractures showed SIR(in/opposed) of less than 1.0, and benign acute compression fractures showed SIR(in/opposed) of greater than 1.0 but SIR(STIR) of greater than 2.0.
Conclusion

In supplementary examination in our institution, when SIR(opposed/in) is less than 1.0, compression fracture bone marrow is suggested to be benign. This is because the signal on opposed-phase images decreases with the fat-rich marrow in cases of benign compression fracture as shown in Figure 1. However, the signal of opposed-phase images was not decreased in cases of malignant disease because the fat in the marrow was replaced by cancer cells.

In addition, TE was shorter in opposed-phase compare to in-phase images. Therefore, the signal intensity was higher in opposed-phase than in-phase images and SIR(in/opposed) was greater than 1.0.

However, cases with SIR(in/opposed) greater than 1.0 included both benign and malignant bone marrow. However, all of these cases with SIR(STIR) greater than 2.0 were benign disease. We postulated that the fat of the marrow is replaced by blood or cell water due to edema in the marrow caused by acute compression fracture. This was occurred high SIR(in/opposed), and addition, very high SIR(STIR), too.

Therefore, acute benign compression fracture can be distinguished from malignant cases due to the high SIR(opposed/in) and very high SIR(STIR) of the former. In addition, discrimination between benign and malignant disease is possible with a boundary of SIR(opposed/in) = 1.0 when cases with high SIR(opposed/in) and high SIR(STIR) are excluded.

There have been many previous studies of differential diagnosis of vertebral compression fracture using diffusion weighted imaging (10 - 12). However, the quality of diffusion weighted images obtained using a surface coil without parallel imaging is poor. Therefore, errors often occur in measurement of the apparent diffusion coefficient (ADC) as it is difficult to set the ROI. At the dominant point of evaluation using the in/opposed phase imaging, it is not effected signal gain because there data was acquired at same acquisition and it not occur the positioning error of the ROIs by the motion and breathing. Therefore, SIR(opposed/in) has very high precision.

We used a comparatively long echo time (TE) for STIR sequence in this study. In calculating the SIR(STIR), it must be remembered that the SIR value depends on both TR and TE. Long TR and TE lead to high contrast STIR images and different SIR(STIR) values. Therefore, long TR and TE were necessary for calculating the SIR(STIR) in this study.

In cases of acute compression fracture, malignant bone marrow showed SIR(STIR) values less than 2.0 and SIR(opposed/in) greater than 1.0.
Representative images (T1WI, STIR images, and opposed/in phase images) of benign and malignant chronic and acute disease are shown in Figures 6 - 9.

The signal intensities of the vertebral compression fractures showed variable patterns, which affect SIR values.

In cases of acute compression fracture, malignant bone marrow showed SIR(STIR) values less than 2.0 and SIR(opposed/in) greater than 1.0. In contrast, benign bone marrow showed SIR(STIR) values greater than 2.0. For chronic compression fracture, malignant bone marrow showed SIR(opposed/in) greater than 1.0. Bone marrow was benign in all cases with SIR(opposed/in) less than 1.0.

Images for this section:

![Fig. 6: Chronic benign compression fracture of the 11th thoracic vertebra (arrow). SIR(opposed/in) was 0.24, and SIR(STIR) was 1.33.](image)
**Fig. 7:** Acute benign compression fracture of the 3rd lumbar vertebra (arrow). SIR(opposed/in) was 1.18, and SIR(STIR) was 2.72.
**Fig. 8:** Chronic malignant compression fracture of the 6th thoracic vertebra (arrow). SIR(opposed/in) was 1.56, and SIR(STIR) was 0.82.
**Fig. 9:** Acute malignant compression fracture of the 11th thoracic vertebra (arrow). SIR(opposed/in) was 1.76, and SIR(STIR) was 1.72.
References


Personal Information