

Assessment of Benign and Malignant Vertebral Fractures Based on the Measurement of the Fat-Fraction

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Introduction: In contrast to most other tissues, vertebral bone marrow (vBM) contains large fractions of fat [1]. Pathologies like osteoporosis or malignant infiltration are known to either change the composition of vBM or to replace vBM, thereby modifying the distribution pattern of fat and water in vBM. Previous studies have applied chemical-shift imaging to differentiate benign from malignant lesions based on the signal ratio of in- and opposed-phase images [2, 3], suffering from a potential ambiguity, because only the dominant component can be determined. In this study we separately quantify the fat (and water) fraction in vertebral bodies and examine the feasibility of these parameters for the differentiation between benign and malignant lesions.

Materials and Methods: 20 patients with pathological fractures ($n=10$) and osteoporotic fractures ($n=10$) were examined at 1.5 T (Magnetom Avanto, Siemens Healthcare, Erlangen, Germany). The protocol included sagittal sequences (T1-weighted TSE, STIR) for the morphological evaluation of focal lesions and the manual selection of regions of interest (ROI) in normal appearing vBM and the lesions. Opposed- and in-phase images of 3 sagittal slices centered over the lesion were acquired with a FLASH sequence ($TE_{opp}=2.38ms$, $TE_{in}=4.76ms$, FOV $300 \times 225mm^2$, slice thickness 5 mm, matrix size 320×240) to calculate the signal ratio of opposed- and in-phase magnitude images ("Opp-In-Ratio") on a ROI basis. For the determination of the fat and water fraction phase images were used in addition to the magnitude images to correctly separate both components.

Results: Parameter maps of the calculated fat fraction and Opp-In-Ratios are shown in Figure 1. Benign and malignant lesions can be clearly delineated as regions of decreased fat fraction and increased Opp-In-Ratio. The values of the fat fraction and Opp-In-Ratio in the lesions and normal appearing vertebral vBM are given in Table 1. Both parameters exhibit significant differences between normal appearing vBM and the fractures ($p<0.01$, unpaired t-test).

Type	Parameter	Fat fraction [%]	Opp-In-Ratio [%]
Osteoporotic	Normal	61.54 (7.45)	27.51 (10.72)
	Fracture	30.14 (25.06)	72.96 (27.40)
Malignant	Normal	40.88 (13.16)	30.03 (16.51)
	Fracture	9.98 (5.95)	87.41 (15.08)

Table 1 Mean (standard deviation) of the Fat-Ratio and Opp-In-Ratio in osteoporotic ($n=15$) and pathological ($n=16$) fractures and in normal vBM.

In contrast to the Opp-In-Ratio, the fat fraction also differs significantly between osteoporotic and pathological vertebral fractures and between normal appearing vBM of both groups. Furthermore the mean values of the ratio of the fat fraction between the lesion and normal appearing vBM per patient were determined as 0.59 (0.45) for patients with osteoporosis and 0.19 (0.12) for malignant fractures. For the Opp-In-Ratio this ratio was 2.40 (1.65) for osteoporotic and 4.18 (1.22) for malignant fractures.

Discussion: The values of the fat fraction and the Opp-In-Ratio showed significant differences between normal and abnormal vBM in patients with benign or malignant lesions. In agreement with previous studies [4] the fat fraction in normal appearing vBM is increased in patients with osteoporosis. The fat fraction in malignant lesions is strongly decreased, since vBM is replaced by cancerous tissue. The fat-fraction was found to be better suited to distinguish between benign and malignant lesions than the Opp-In-Ratio and might serve as a tool for the differentiation of osteoporotic and malignant vertebral compression fractures. While the Opp-In-Ratio is only able to discriminate a change of the dominant component in the ROI, the determination of the fat/water-ratio is unambiguous.

References: [1] Vogler, Radiology 1988;168:679, [2] Zajick, Radiology 2005;237:590-596, [3] Zampa, Eur Radiol 2002, 1811.1818, [4] Griffith, Radiology 2005;236:945-951

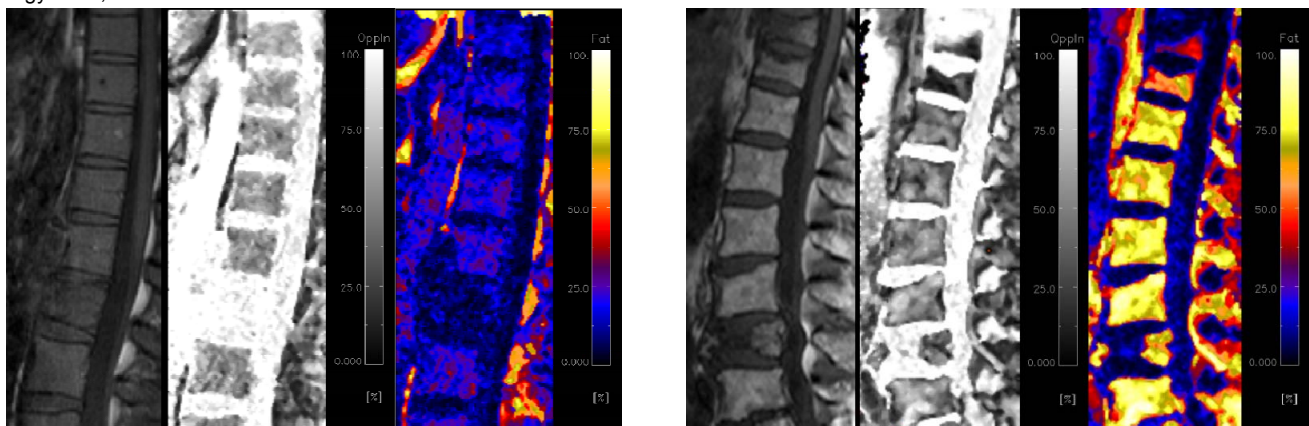


Figure 1: Parameter maps of the Opp-In-Ratio (middle) and fat fraction (right) for a patient with osteoporotic fractures (T10, T11) (left side) and a patient with a pathological fracture (L2) (right side). For reference a T1w image is shown (left).