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THE IMPORTANCE OF DIFFUSION MRI IN EVALUATION OF VERTEBRAL METASTASES

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ABSTRACT

Objective: The contribution of diffusion-weighted MRI to differential diagnosis between metastasis-pathologic vertebral fracture and osteoporotic vertebral fracture was investigated.

Materials and Method: This study included (group-1) 14 benign vertebral fractures and (group-2) 42 vertebral metastases, all patients were investigated with vertebral X-ray, spine MRI and diffusion MRI and followed up for 1 year. Scintigraphy examination of the second group of patients were available.

Results: In group-1, all compression fractures were no restricted diffusion and hypointensity on MRI. In the second group, 25 vertebral lesions were detected hyperintense, 6 moderate hyperintense, and 11 hypointense signals. Diffusion MRI hyperintensity was detected significant in metastatic lesions ($p < 0.001$). Group 2 was separated as lytic and sclerotic subgroups. Diffusion restriction, hyperintensity signal was significantly higher in lytic metastases ($p < 0.001$).

Conclusion: Diffusion-weighted MRI contribute to the conventional MR sequences in the case of lytic vertebral metastasis. Diffusion-weighted imaging has limited diagnostic value in sclerotic metastases.

Keywords: Metastases, vertebra, diffusion MRI, sclerotic metastases, lytic metastases.
Level of evidence: Retrospective clinical study, Level III.

INTRODUCTION

Vertebral metastasis is observed in 10% of all malignant neoplasms [(7)]. The diagnosis of vertebral metastasis is important to guide the patient's treatment. For the diagnosis of vertebral metastasis, scintigraphy, X-ray, CT and especially MRI are used. Scintigraphy is not sufficient to differentiate between degeneration and inflammation-metastasis [(6,8)]. Metastasis can be detected on X-ray and scintigraphy only when cortical destruction occurs in the vertebra [(9)]. Before the development of cortical destruction, bone marrow eudema can be shown by MRI. In addition, soft tissue coexistence and extension can be detected due to high soft tissue resolution.

The differential diagnosis of vertebral height loss due to vertebral metastasis and osteoporotic vertebral fracture can be difficult despite all the diagnostic methods. These two types of vertebral fractures are seen in the same age group. When the vertebral fractures occur in osteoporotic patients with malignancy, the distinction between benign and malignant fractures becomes more difficult. The morphological differences in the differentiation of benign and malignant vertebral fractures (MVF) have been described in detail. In osteoporotic or traumatic benign vertebral fractures (BVF), pedicle and posterior arch are normal, epidural soft tissue mass is not expected [(5)]. The presence of an avulsion fracture at the posterior vertebral corner on CT is characteristic for BVF. Chronic phase BVF is shown isointense signal on T1W and T2W, and no contrast enhancement on the MRI [(1)]. Acute phase BVF, due to edema in the bone marrow, is shown T1W hypointense-

T2W hyperintense signals, and homogeneous contrast enhancement. Therefore, acute BVF and MVF signals are similar and may be difficult to discriminate based on signal characteristics. In MVF, an epidural mass-pedicle-posterior arch invasion are expected and T1W hypointensity, T2W hyper-iso-hypointensity signals, heterogeneous enhancement on MRI [1-3].

We investigated the contribution of diffusion-weighted MRI to the differential diagnosis of BVF from known metastatic vertebral lesions and malign vertebral fractures.

MATERIALS AND METHODS

A total of 30 patients were included in the study between 2001 and 2003.

Grou-1 consisted of 14 patients with acute OVF. None of the patients had known malignancy. Patients who were diagnosed with osteoporosis with bone densitometry and medication for the last 3 months due to severe back pain were followed up for 1 year. No malignancy was detected during follow-up.

Group-2, a total of 42 vertebrae metastases were detected in 18 patients, 12 breast cancer, 2 prostate cancer, 2 lung cancer, 2 patients with unknown of primary malignancy with multiple organ metastasis. In these patients with known primary malignancy or multiple metastasis, invasion of pedicle-posterior arch and soft tissue coexistence were determined as the main criteria. The patients were followed up for at least 1 year.

Exclusion criteria:

Patients with suspected metastasis and without histopathologic diagnosis, patients without follow-up.

1.5 Tesla Philips Gyroscan ACS-NT MR and spinal coil are used. Sagittal T1W-T2W FSE-Diffusion (EPI b: 600) and Ax T2-W FSE images were obtained. Sagittal T1-W FSE (425/7 repetition time/echo time, 320x256 matrix, 300-mm field of view and 4-mm section thickness, NEX 3), T2-W frFSE and an axial T2-W frFSE (3357/120 repetition time/echo time, 320x256 matrix, 300-mm field of view and 4-mm section thickness, NEX 3) was imaged for the study. In addition, thoracic and lumbar X-ray were performed.

The number of affected vertebrae, vertebral shape, vertebral region (corpus-posterior component involvement), T1W-T2W-diffusion MR signals were recorded in each patient.

In the comparison of the two groups, age variable was compared with independent samples *t*-test. Nominal variable was compared by Chi-square with Yates correction and Fisher's exact probability tests. $P < 0.05$ was considered statistically significant. NCSS (10 http://vassarstats.net/fisher2x4.html) was used for analysis.

RESULTS

Group-1 (BVF): A total of 14 patients; 8 female and 4 males, mean age 64.91 (minimum 49, maximum 78 years). In 14 patients, 10 BVF was defined as an acute period (less than 3 months pain, trauma history) and 4 BVF was defined as a chronic period (longer than 3 months).

In the first group, there was a loss of height above 15% in all vertebrae, biconcave or anterior wedge shape. MRI showed all of them hypointense on T1W images, 10 BVF was hyperintense and 4 BVF was isointense on T2W images. All the diffusion MRI was low-signal, not restricted diffusion (Figure-1).

No epidural, paravertebral soft tissue mass, no invasion of pedicle or posterior arch was observed in any of them (Table-1).

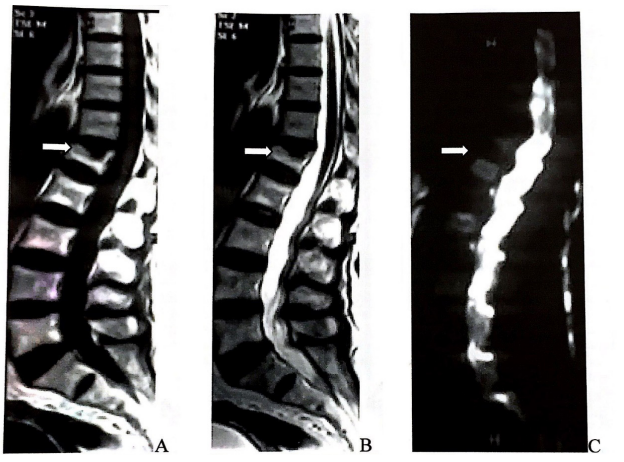

Figure-1. A 71-years-old female patient without malignancy **(a)** Sagittal T1W MRI, vertebral height loss was detected on first lumbar vertebra and isointense signal**. (b)** Sagittal T2W MRI showed loss of height in the L1 vertebra and isointense signal. **(c)** Diffusion MRI, L1 vertebra is isointense, there is no diffusion restriction: evaluated as a chronic stage benign vertebral fracture.

Table-1. Comparison of diffusion restriction between group 1 and group 2. (DR: diffusion restriction, P, Fisher exact probability test).

	DR (-)	DR (+)	DR (mildly hyperintense)
GROUP 1 (n=14)	14	0	0
GROUP 2 (n=38)	11	21	6
p		<0.001	

Group-2 (metastasis and malignant vertebral fractures): 14 women and 4 men, 18 patients had 42 vertebral lesions. Average age 58,27 (minimum 40, maximum 86 years). 4 vertebrae were followed by malignant fracture and 20 vertebrae had a loss of height below 10%. In all cases, cortical destruction, invasion of pedicle or posterior arch, soft tissue mass, existence of multisite were present at least one.

After the MRI and X-ray correlation, 38 lytic and 14 sclerotic metastases were defined. All of the metastases were hypointense signal on T1W, 25 hyperintense lesions and 17 hypointense lesions were seen on T2W MRI. Of these 17 hypointense lesions, 14 lesions were sclerotic.

In the evaluation for 4 malign vertebral fractures, all of them was detected hypointense signal on T1W, hyperintense signal on T2W and restricted diffusion (hyperintense) on MRI (Figure-2).

Other 38 metastatic lesions in the second group, diffusion MRI signals differ in vertebral metastasis. For lytic metastases, twenty-one of 24 lytic metastases were restricted diffusion, while 3 lytic metastases were mildly hyperintense. For sclerotic metastases, eleven of 14 sclerotic metastases were hypointense, no restriction in diffusion MRI and 3 mildly hyperintense signals (Figure-3).

In patients with multiple vertebrae metastasis, millimetric nodular lesions which do not show pedicle involvement were accepted as metastasis. An invasion of pedicle was detected in all MVF and in %68 of the metastases (Table-2).

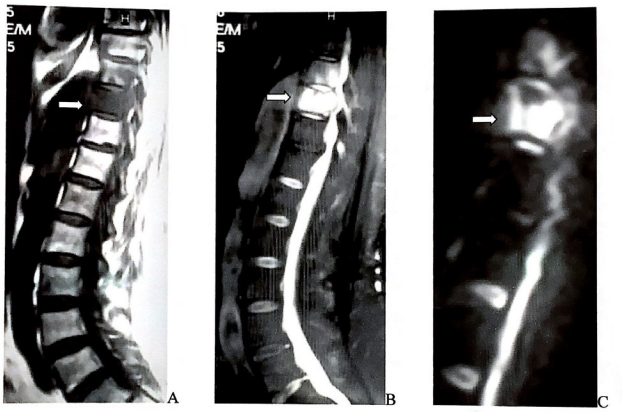

Figure-2. A 53-years-old female patient with lung cancer, **(a)** T9 and T10 vertebra vertebra were hypointense and minimal height decrease on T1W sagittal image. **(b)** T2W sagittal image showed hyperintensity in T9 and T10 vertebrae. **(c)** Diffusion restriction was observed, evaluated as metastasis.

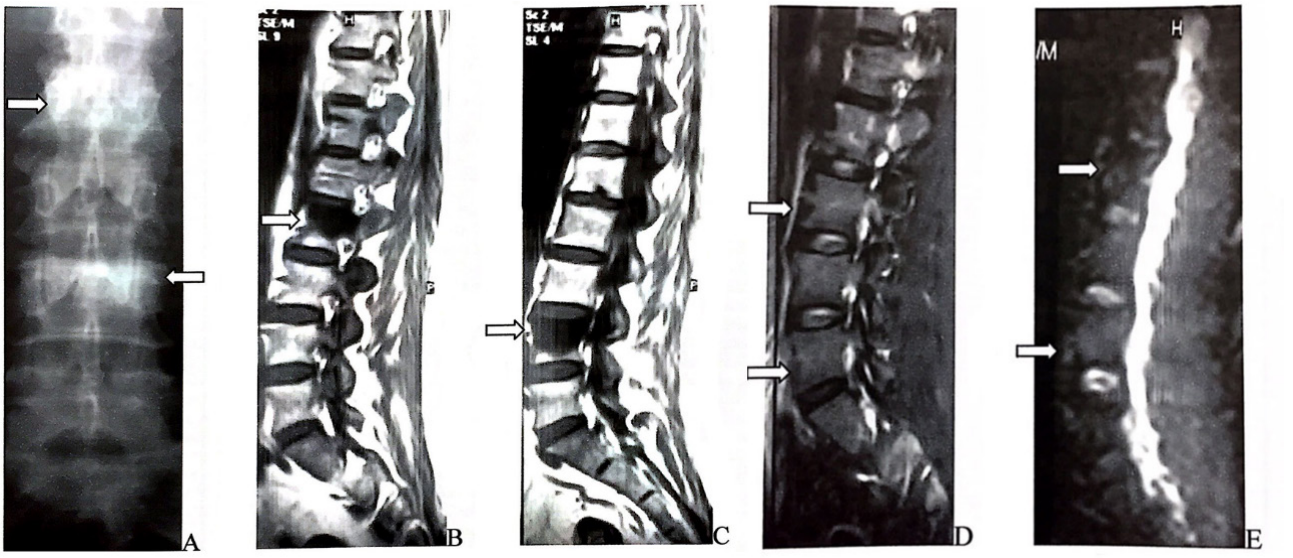

Figure-3. A 53-years-old female patient with breast cancer; **(a)** on the lumbar X-ray were detected sclerotic lesions on the pedicles of L2 and L4 vertebrae. **(b)** T1W sagittal image showed a iso-hypointense lesion on the L2 vertebra. **(c)** T1W sagittal image showed a iso-hypointense lesion on the L4 vertebra. **(d)** L2 and L4 vertebrae were isointense on T2W sagittal image.

Table-2. Comparison of diffusion restriction of lytic and sclerotic metastases in the group 2. (DR: diffusion restriction, P, Fisher exact probability test).

GROUP 2 (n=38)	DR (-)	DR (+)	DR (mildly hyperintense)
Lytic (n=24)	0	21	3
Sclerotic (n=14)	11	0	3
p		<0.001	

Restricted diffusion, hyperintensity was significantly higher in metastatic lesions compared to BVF (p<0.001, Fisher exact probability test).

Restricted diffusion was significantly higher in lytic metastases (p<0.001).

Restricted diffusion, hyperintensity was significantly higher in lytic metastasis than sclerotic metastases (p<0.001, Fisher exact probability test).

DISCUSSION

In our study, T1W hypointensity and T2W hyperintensity were detected in all acute period BVF due to marrow edema. In all chronic period BVF was observed T1W and T2W isointensity. Due to these signal characteristics, the chronic period BVF can be easily diagnosed, but the acute BVF and MVF differentiation cannot be performed according to the T1W-T2W signals, because of the same signal on T1W-T2W MRI can be seen in MVF. Considering the diffusion MRI, in our study, all MVF showed diffusion restriction; any of BVF showed no diffusion restriction.

Diffusion MRI was found to be useful in the differentiation of MVF and BVF. Consistent with our study, Baur et al. [2] reported pathologic diffusion restriction in all MVF and suggesting that diffusion MRI was a very good method in the differentiation of BVF and MVF. Zhou et al. [10] reported that the diffusion MRI and ADC evaluation were useful in differential diagnosis of metastasis with BVF. On the other hand, Castillo et al. [4] reported that diffusion MRI was not superior to T1W image in their study. One of the reasons for differences that lytic and sclerotic metastasis were not separated in the study. In our study, in all 24 lytic metastases, 21 lytic metastases were shown restricted diffusion on MRI, while mildly hyperintense were shown in 3 lytic metastases. Eleven of 14 sclerotic metastases were hypointense and 3 mild hyperintense on diffusion MRI. In our study, the distinction of lytic vertebral metastases could be performed on diffusion MRI. On the other hand, diffusion MRI is not useful in the differentiation of sclerotic metastasis from BVF.

Our limitations; increasing the number of patients can be done in larger series.

In conclusion, the signal characteristics of T1W-T2W sequences overlap in acute BVF and MVF. Diffusion-weighted imaging is guiding in the differential diagnosis of acute BVF and MVF. Diffusion restriction is not detected in acute BVF but detected in MVF. It should be kept in mind that sclerotic metastases may not appear diffusion restriction while lytic vertebral metastases may have diffusion restriction.

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