Differentiation of osteoporotic and neoplastic vertebral fractures by chemical shift (in-phase and out-of-phase) MR imaging

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Received 1 March 2008; received in revised form 9 June 2008; accepted 12 June 2008

Abstract

Objective: The objective of this study was to establish the cut-off value of the signal intensity drop on chemical shift magnetic resonance imaging (MRI) with appropriate sensitivity and specificity to differentiate osteoporotic from neoplastic wedging of the spine.

Patients and methods: All patients with wedging of vertebral bodies were included consecutively between February 2006 and January 2007. A chemical shift MRI was performed and signal intensity after (in-phase and out-of-phase) images were obtained. A DXA was performed in all.

Results: A total of 40 patients were included, 20 with osteoporotic wedging (group 1) and 20 neoplastic (group 2). They were 21 males and 19 females. Acute vertebral collapse was observed in 15 patients in group 1 and subacute collapse in another 5 patients, while in group 2, 11 patients showed acute collapse and 9 patients (45%) showed subacute vertebral collapse. On the chemical shift MRI a substantial reduction in signal intensity was found in all lesions in both groups. The proportional changes observed in signal intensity of bone marrow lesions on in-phase compared with out-of-phase images showed significant differences in both groups (P < 0.05). At a cut-off value of 35%, the observed sensitivity of out-of-phase images was 95%, specificity was 100%, positive predictive value was 100% and negative predictive value was 95.2%.

Conclusion: A chemical shift MRI is useful in order to differentiate patients with vertebral collapse due to underlying osteoporosis or neoplastic process.

Keywords: Vertebral fractures; Osteoporotic fractures; Neoplastic fractures; Chemical shift MRI (in-phase and out-phase); Opposed-phased imaging; DXA measurements

1. Introduction and aim of the work

Differentiating benign from malignant vertebral marrow processes has been an important and sought after goal of imaging. Although magnetic resonance (MR) imaging is a sensitive method for assessing bone marrow, it lacks specificity. Chemical shift MR imaging (also known as in-phase and out-of-phase imaging or opposed-phased imaging) can demonstrate small quantities of fat in the tissue and has proved to be effective in facilitating distinction between malignant and benign processes.
2. Patients and methods

All patients were included with acute onset of spinal pain and unambiguous radiograph images of acute wedging of single or multiple vertebral bodies with wedging of vertebral bodies consecutively between February 2006 and January 2007. A total of 40 patients could be included, 21 males and 19 females. There were 20 with osteoporotic wedging (group 1) and 20 with neoplastic wedging (group 2). All patients underwent a plain X-ray for the affected spine followed by MRI/chemical shift MRI as early as possible after the initial complaint.

Para-vertebral soft tissue extension, infiltration of posterior elements, and presence of multiple metastases of the vertebral bodies on initial MR images were considered important findings in support of a neoplastic fracture. Further work up was performed for all patients in group 2 (N = 20), the diagnosis of the underlying malignancy was confirmed by biopsy from the primary lesion and bone biopsy from the affected Vertebral/vertebrae in case of metastatic spinal lesions. None of the patients received radiotherapy before the study to avoid signal alteration on chemical shift MRI.

In all patients, a DXA bone densitometry (Norland XR-36 DXA machine) was performed on the lumbar spine, hip and radius, regardless of the site of the primary lesion, and results of both groups were compared.

2.1. MR imaging technique

Magnetic resonance imagining was performed for all patients by using a 1 and 1.5-T Magnetom expert Semines and General Electric Echo speed imager and a phased-array spine coil. The following pulse sequences were used for all patients: sagittal T1-weighted spin-echo [400–700: repetition time ms and 8–16: echo time ms] MR imaging. Sagittal T2-weighted fast spin-echo (2000–5000/80–100), MR imaging sagittal short (TAO) inversion-recovery (STIR) [2000–4000: repetition time ms/20–60 echo time ms/150 inversion time ms]. Sagittal in-phase (100–165/2.1; flip angle, 30°) and out-of-phase (100–165/2.1; flip angle, 30°) fast multiplanar spoiled gradient-echo MR imaging.

For chemical shift MR imaging, the total imaging time was 40–50 s for the entire pulse sequence. All previously mentioned parameters are constant for acquisition of in-phase and out-of-phase images. For all sagittal sequences, the field of view was 20 cm for cervical vertebrae, 34 cm for thoracic vertebrae, and 24 cm for lumbar/sacral vertebrae. The matrix was 256 × 192, and the section thickness and gap were 4.0 mm, with a skip of 1.0 mm.

The fluid sign was defined as a focal, linear, or triangular area of strong hyperintensity on STIR images on a background of diffuse hyperintensity in the vertebral body because of acute collapse. The signal intensity of the fluid sign had to be equivalent to that of cerebrospinal fluid [1], Fig. 5.

2.2. Statistics

The proportional change (percentage decrease) of marrow signal intensity on out-of-phase images compared with in-phase images was calculated for each lesion in both groups. The Mann–Whitney test was applied for comparison of non-parametric variables and the Pearson’s test was used for correlations (statistical significance were inferred at P-value < 0.05). ROC (Receiver Operating Characteristic) curve was used to obtain the best cut-off value for chemical shift technique and to obtain false negative and false positive rates for every possible cut-off value.

2.3. Ethics

All patients gave informed written consent to be enrolled in this study, according to the Declaration of Helsinki, and the local ethics committee approved the study.

3. Results

The study group comprised 40 consecutive patients (21 males and 19 females) with acute vertebral compression fractures due to osteoporotic (N = 20) (group 1); their mean age (±S.D.) in years was 62.8 ± 9.2 and neoplastic fracture (N = 20) (group 2) with mean age (±S.D.) of 49.9 ± 9.0 years.

Single vertebral collapses were observed in 15 patients (75%) and multiple vertebral collapses in 5 patients (25%) in group 1 (Figs. 1 and 2), while in group 2, single vertebral collapse was observed in 7 patients (35%), and multiple vertebral collapses in 13 patients (65%) (Figs. 3 and 4). A total of 71 abnormal vertebral bone marrow signal alterations were evaluated in groups, 20 lesions (28.2%) in group 1, and 51 lesions (71.8%) in group 2. Acute vertebral collapse was observed in 15 patients (75%) in group 1 and subacute collapse in another 5 patients (25%), while in group 2, 11 patients (55%) showed acute collapse and 9 patients (45%) showed subacute vertebral collapse. Fluid sign on MRI was observed in 13 patients (65%) in group 1 compared to 2 patients (10%) in group 2. Para-vertebral invasion was observed in only three patients in group 2 (Figs. 3 and 4 and Table 1). The types of underlying tumor in group 2 are summarized in Table 1. The underlying malignancy was known in 15 out of 20 patients studied in group 2 before developing spinal pain suggestive of
Fig. 1. Benign osteoporotic collapse of L3 and L4 (white arrows) showing significant signal drop on out of phase images.

Fig. 2. Multiple vertebral benign osteoporotic wedging, STIR sequence shows marrow edema parallel to the end plate (white arrows) of D9, D11, L3 and L4 vertebrae with corresponding enhancement on T1—gadolinium fat sat images. All show significant signal drop on out of phase images consistent with benign collapse.
metastatic disease and further confirmation by bone biopsies from the spinal lesions was carried out in all patients in group 2 N=20. Biopsies from the primary lesions were carried out in 16 out of 20 patients in group 2 (prostate N=3, breast N=6, lymph node N=2, trans bronchial lung biopsy N=3, kidney N=2).

3.1. Bone mineral density (BMD)

$t$ scores in the spine were similar in both groups. However $t$-scores at the hip and distal radius were significantly lower in group 1 than the corresponding results in group 2 (FN: $-3.0 \pm 0.84$ vs. $-2.25 \pm 1.05$ $t$-score, $P=0.03$; and radius: $-3.22 \pm 1.17$ vs. $-2.21 \pm 1.15$ in group 2 ($P=0.014$) (Fig. 1 and Table 2). Nevertheless, substantial overlap of BMD values occurred between groups, since in group 1 10 patients fell in the osteopenic range ($t$-score $-1$ to $-2.5$) and 10 patients fell in the osteoporotic range ($t$-score $<-2.5$), while in group 2, two patients showed normal BMD results, 11 patients (55%) were osteopenic, and 7 patients (35%) had osteoporosis ($t$-score $<-2.5$) (Table 1).

The MRI in-phase between both groups showed no significant differences, while the out-of-phase MR chemical shift was significantly different between both groups, being less in group 1 (110.78 ± 31.63) compared to group 2 (219.15 ± 76.1) (Table 3).

Although we observed some overlap in the range of signal intensity values between both groups, we found that a signal drop greater than 35% on out-of-phase images compared with in-phase images can be used as a cut-off value to differentiate between both conditions. At this cut-off value, the observed sensitivity was 95%, specificity was 100%, positive predictive value was 100% and negative predictive value was 95.2%.

4. Discussion

Benign compression fractures of vertebral bodies may pose a diagnostic dilemma in patients with primary neoplasms and suspected skeletal metastases or in elderly patients without a known, but potential, primary tumor [1]. The problem is that abnormal signal intensity in benign compression fractures on conventional MR imaging can be similar to that seen in vertebrae with underlying malignancy. Although certain morphologic signs may be helpful for assessing the cause of the fracture yet these lack specificity, such as the degree and pattern of bone marrow replacement, para-vertebral soft-tissue masses, and infiltration of posterior elements of the vertebrae.

In this current study we hypothesized that in-phase/opposed-phase imaging of the spine can be a sensitive and specific method for differentiating benign osteoporotic from malignant vertebral collapse. The presence of both fat and water in normal marrow results in suppression of signal intensity on the
opposed-phase images. In benign osteoporotic collapse, no marrow replacement has occurred, thus the existence of normal marrow fat should result in suppression of signal intensity on the opposed-phase images; while in malignant collapse the normal fat-containing marrow is replaced with tumoral process which should result in lack of suppression on the opposed phase images.

In a series of 53 patients, Baker et al. [4] found that acute benign fractures more often show inhomogeneous low signal intensity on T1-weighted spin-echo and fat-suppressed images and inhomogeneous high signal intensity on T2-weighted and STIR images. In contrast, pathologic fractures showed more homogeneous replacement of the bone marrow which reflects bone marrow replacement by tumor cells. Para-vertebral soft-tissue masses and infiltration of posterior elements are another important and more reliable signs of a malignant fracture [5].

In our study, we observed para-vertebral lesions in 3 patients (15%) in group 2. Given that, the absence of these findings does not always exclude a malignant process.

Chemical shift has been used extensively in imaging of the liver and adrenal glands. The technique takes advantage of different procession frequencies of water and fat protons due to the differences in their molecular environment. Because they process at slightly different frequencies, at 1.5 T, water and fat protons are in phase with one another at a TE of 4.6 ms, and 180° opposed at a TE of 2.4 ms [4].

The findings in this current study are consistent with and extend those from previous reports that have described in-phase/opposed-phase imaging of the spine and marrow [4–8].

Most recently, Eito et al. [5] compared the signal intensity ratios (SIRs) of normal and neoplastic compression-fractured vertebrae in 108 patients by means of dual-phase chemical shift MRI. Their study comprised three groups; group 1: normal vertebrae (N=30); group 2: non-neoplastic compression fractured vertebrae (N=58); and group 3: neoplastic compression-fractured vertebrae (N=20). The mean SIRs of the three groups appeared to be significantly different. They concluded that opposed-phase and in-phase gradient-echo MR imaging of vertebral signal intensity abnormalities can help predict the nature of compression fractures. Erly et al. [6] used the same technique as the current study, to differentiate between benign and malignant fractures of the spine. The authors evaluated 25 consecutive patients with suspected malignancy [lymphoma N=4, breast cancer N=3, multiple myeloma N=2, melanoma N=2, prostate N=2, and renal cell carcinoma N=1] for trauma to the thoracic or lumbar spine. Areas that were of abnormal signal intensity on the T1 and T2 sequences were identified on the in-phase/opposed-phase sequences. Con-
Fig. 5. (A) STIR sequence showing linear bright signal at the upper end plate of L3 (fluid sign) with a background of mild hyper-intensity. (B) T1WI showing hypointensity parallel to the upper end plate of L3.

sistent with our study Erly et al. [6] found significant difference ($P<0.001$) in the mean SIR for the benign lesions compared with the malignant lesions. As in our study, they observed a substantial decrease in signal intensity in all lesions whether neoplastic or osteoporotic.

Our results also are in agreement with those of Zajick et al. [7] who retrospectively assessed the use of chemical shift magnetic resonance (MR) imaging technique in differentiating benign from malignant marrow abnormalities. The authors examined a total of 569 normal vertebrae in 75 patients (42 women, 33 men; mean age, 57.5 years; age range, 26–84 years) (control group) and 221 lesions in 92 patients (50 women, 42 men; mean age, 59.0 years; age range, 27–85 years) (study group) who had focal vertebral marrow abnormalities by using 1.5-T chemical shift MR imaging. Consistent with our study Zajick et al. [7] found a substantial decrease in signal intensity for all normal vertebrae and for benign lesions. In contrast to our study, they suggested that a decrease in signal intensity greater than 20% on out-of-phase images compared with in-phase images should be used as a cut-off threshold for normality to allow distinction between benign and malignant causes of vertebral marrow abnormalities. While our results showed that a signal drop greater than 35% on out-of-phase images compared with in-phase images can be used as a cut-off value to differentiate between both conditions. At this cut-off value, the observed sensitivity was 95%, specificity was 100%, positive predictive value was 100% and negative predictive value was 95.2%. The discrepancy in the cut-off value obtained in our study compared to Zajick et al. [7] may be explained by the difference in the type of lesions. Zajick et al. [7] examined endplate degeneration, Schmorl nodes with edema, hemangiomas, benign fractures and different patterns of metastatic lesions which stratified in their study into three different categories: lytic, blastic, or mixed. In our study we focused only on evident osteoporotic and neoplastic wedging. It should be noted that bone marrow lesions in the vertebral bodies due to different pathologies may displays somewhat variable behavior at chemical shift MR imaging. Nevertheless, Zajick et al. [7] observed that 8 (16%) of 51 lesions demonstrated a decrease in signal intensity that was greater than 20%. Of the lesions that demonstrated false-negative findings at chemical shift MR imaging, four had a decrease in signal intensity that was greater than 40%, with the greatest decrease in signal intensity being 75.9%. The authors stated that this overlap is in part related to the lesion subtype. Lytic lesions loose less signal intensity than blastic lesions. The substantial number of metastases that could not be characterized (unknown lesions) in their study also contributed to the variable behavior of malignant lesions at chemical shift MR imaging.

Chemical shift MR imaging can demonstrate the relationship between the amount of fat and water that coexist in the same voxel. Osseous elements, however, will also affect this relationship; thus, the degree of signal intensity change may not be proportional to the quantity of hematopoietic marrow alone. Hemangiomas for example are slow growing, benign neoplasms
Table 1
Demographic features, radiological features and clinical characteristics among the studied groups of patients

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Osteoporotic (N = 20)</th>
<th>Neoplastic (N = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex M/F</td>
<td>8/12</td>
<td>13/7</td>
</tr>
<tr>
<td>Age (years)</td>
<td>62.8 ± 9.2</td>
<td>49.9 ± 9.0</td>
</tr>
<tr>
<td>Mean age of fracture (days)</td>
<td>13 ± 6.3</td>
<td>22 ± 6.3</td>
</tr>
<tr>
<td>Time from symptom to MRI study</td>
<td>25 ± 7</td>
<td>53 ± 5.6</td>
</tr>
<tr>
<td>Failure location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single vertebral collapse</td>
<td>15/20</td>
<td>7/20</td>
</tr>
<tr>
<td>Multiple vertebral collapse</td>
<td>5/20</td>
<td>13/20</td>
</tr>
<tr>
<td>Acute wedging</td>
<td>15/20</td>
<td>11/20</td>
</tr>
<tr>
<td>Subacute wedging</td>
<td>5/20</td>
<td>9/20</td>
</tr>
<tr>
<td>Para-vertebral soft tissue invasion</td>
<td>0/20</td>
<td>3/20</td>
</tr>
<tr>
<td>Fluid sign</td>
<td>13/20</td>
<td>2/20</td>
</tr>
<tr>
<td>Fracture location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cervical</td>
<td>0/20</td>
<td>6/20</td>
</tr>
<tr>
<td>Dorsal</td>
<td>15/20</td>
<td>7/20</td>
</tr>
<tr>
<td>Lumbar</td>
<td>5/20</td>
<td>7/20</td>
</tr>
<tr>
<td>Underlying malignancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prostate cancer</td>
<td>–</td>
<td>3</td>
</tr>
<tr>
<td>Breast cancer</td>
<td>–</td>
<td>6</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>Bronchial carcinoma</td>
<td>–</td>
<td>3</td>
</tr>
<tr>
<td>Nephroma</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>Multiple myeloma</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td>DXA lumbar spine results at the time of the study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Osteopenia (t-score −1 to −2.5)</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Osteoporosis (t-score &lt; −2.5)</td>
<td>10</td>
<td>7</td>
</tr>
</tbody>
</table>

* Data are the mean (±S.D.).

that are commonly found in the vertebral bodies. Histopatho-
logically, they consist of thin-walled, blood-filled vessels and
sinuses that are lined by endothelium, are interspersed among
the bone trabeculae, and have a variable amount of fat. Some,
such as those with predominant fat content, do not demonstrate
a decrease in signal intensity because there are few or no non-
lipid elements. However atypical hemangiomas, which contain
only small or microscopic quantities of fat, may demonstrate
the utility of chemical shift MR imaging because they will lose
signal intensity on out-of-phase images [7].

Zampa et al. [8] evaluated 86 vertebral lesions by using an
MR protocol consisting of a T1-weighted spinecho and an out-
of-phase gradient-recalled echo MR imaging sequence. They
observed that a cut-off value of 1.2 resulted in 88.8% sensitivity,
80.5% specificity, 84.9% accuracy, 86.4% negative predictive
value, and 83.3% positive predictive value. They concluded that
lesions with values that were higher than the cut-off value were
considered neoplastic, whereas lesions with values that were
lower than the cut-off value were considered benign.

In a study by Disler et al. [9] was found that signal inten-
sity abnormalities can help predict the likelihood of neoplastic
or non-neoplastic lesions in 31 non-spine lesions. The authors
expressed their findings as a relative ratio that compared the sig-
nal intensity in abnormal bone marrow to that of a control site
on out-of-phase and in-phase images. This relative ratio was cal-
culated as the ratio of signal intensity on out-of-phase images
divided by the ratio of signal intensity on in-phase images. By
using this formula, Disler et al. [9] calculated an average rela-
tive signal intensity ratio of 1.03 for the neoplastic group and
0.62 for the non-neoplastic group (P < 0.0001). They found that
a ratio cutoff value of 0.81 resulted in 95% sensitivity and 95%
Specificity for the detection of neoplasms. In contrast to Disler
et al. [9] we studied only the spinal lesions and did not perform
qualitative assessment of the changes in signal intensity on in-
phase images compared with out-of-phase images and did not
compare affected and non-affected vertebrae as control sites for
the same patients. In our opinion one can never exclude tumor
tissue in these vertebrae.

The fluid sign which is defined as a focal, linear, or triangular
area of strong hyperintensity on STIR images on a background
of diffuse hyperintensity in the vertebral body because of acute
collapse may be regarded as an additional morphologic feature
that supports the benign osteoporotic nature of an acute fracture.
Although this finding is significant, a tumor cannot be excluded
because of this sign [1]. In our study, fluid sign was observed
more frequently in group 1 (13/20) than in group 2 (2/20). This
is consistent with findings observed by Baur et al. [1] who evalu-
ated the occurrence, location and shape of the fluid sign in acute
osteoporotic and neoplastic vertebral compression fractures due to
magnetic resonance (MR) imaging in 87 consecutive patients
with acute vertebral compression fractures due to osteoporotic
(N = 52) or neoplastic (N = 35) infiltration. They found that
the fluid sign was significantly associated with osteoporotic frac-
tures (P < 0.001). They concluded that the fluid sign is featured
in acute vertebral compression fractures that show bone marrow
edema. It can be an additional sign of osteoporosis and rarely
occurs in metastatic fractures.

Recently, diffusion-weighted sequences have been proposed
as a helpful adjunct in the differentiation of acute benign osteo-
porotic fractures from pathologic fractures of the spine [10].
Diffusion-weighted sequences are sensitive to molecular motion
because random motion of water molecules in gradient fields

Table 2
Comparison of dual energy X-ray absorptiometry (DXA) results in both groups

<table>
<thead>
<tr>
<th>Group 1 no = 20, osteoporosis, mean ± S.D.</th>
<th>Group 11 no = 20, neoplastic, mean ± S.D.</th>
<th>P-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DXA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spine</td>
<td>−2.58 ± 1.01</td>
<td>−2.21 ± 1.04</td>
<td>0.3</td>
</tr>
<tr>
<td>Hip</td>
<td>−3 ± 0.84</td>
<td>−2.25 ± 1.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Radius/Ulna</td>
<td>−3.22 ± 1.17</td>
<td>−2.21 ± 1.15</td>
<td>0.014</td>
</tr>
</tbody>
</table>

DXA = dual energy X-ray absorptiometry.
produces phase dispersion and, therefore, signal attenuation. Water in vital tumor cells shows lower mobility as a result of cellular structures [11]. In the presence of diffusion-sensitizing gradients, this finding should result in a lower signal attenuation compared with stronger dephasing of more mobile extracellular water with extensive signal attenuation. Accordingly, diffusion-weighted imaging should differentiate benign (osteoporotic and traumatic) and malignant vertebral fractures [12]. Hypo- or iso-intense signal intensity in an acute vertebral compression fracture indicates a benign osteoporotic fracture, whereas hyper-intensity indicates a metastatic fracture. Hypo- or iso-intense signal was diagnostic for an acute benign fracture, whereas high signal intensity was suggestive of pathologic bone marrow infiltration. The low signal intensity of acute benign vertebral compression fractures on diffusion-weighted images may be due to bone marrow edema, leading to an increase in the mean free path length of water protons and therefore to a signal loss in the fractured areas. Moreover increasing diffusion weighting can reduce false-positive hyperintense osteoporotic fractures or make hypointensity more obvious in cases of osteoporotic fractures. It is noteworthy to mention that if the findings on routine T1-weighted SE and STIR images are not completely conclusive for a diagnosis of acute benign or pathologic vertebral compression fracture, then diffusion-weighted imaging of the spine is indicated [13].

In our study, although the mean age in years in group 1 was \{62.8 ± 9.2\} and in group 2 was \{49.9 ± 9.0\}, the assessment of bone mineral density in group 1 showed that 10 patients fell in the osteopenic range (t-score −1 to −2.5) and 10 patients fell in the osteoporotic range (t-score < −2.5). While in group 2, two patients showed normal BMD results, 11 patients were osteopenic, and 7 patients had osteoporosis (t-score < −2.5). This overlap in DXA readings between both groups can be explained by the fact that malignancy can induce early bone loss and this was explained by Hung et al. [14] who compared spinal BMD in 50 patients with invasive cancer of the cervix without bone metastases and 50 control women. In their study none of the patients and control women had reached menopause. They found that BMD in patients with cervical cancer was significantly lower (P < 0.05) than those of control women, similar results were also observed by Cho et al. [15]. Further more discrepant findings on spinal BMD may be observed depending on the type of malignancy, presence or absence of spinal metastasis, pattern of spinal metastasis [osteoblastic versus osteolytic] and hormonal therapy as well. Spinal BMD in stage IV patients with bone metastases due to prostate cancer was described by Chang et al. [16] who evaluated BMD results of lumbar spines in 30 prostate cancer patients with lumbar spine metastases and compared these measurements of BMD in lumbar spines with 30 patients with stage IV prostate cancer patients without lumbar spine metastases. The authors found significantly higher BMD of the lumbar spines in the 30 patients of prostate cancers with lumbar spine metastases (P-value < 0.05) and concluded that patients of prostate cancers with lumbar spine metastases had increased BMD in the lumbar spines, possibly because of a predominance of osteoblastic over osteolytic metastases demonstrated by bone scan; on the contrary those patients with advanced prostate cancer requiring androgen deprivation therapy (ADT) had a high incidence of osteoporosis before treatment. It was recommended that BMD should be used in all patients with advanced cancer prostate requiring ADT [17].

Our study had some restrictions: the overall sample size (N = 40) was not large enough to establish a robust normal range, despite the fact that we evaluated a total of 71 lesions. We had no control data from non-affected vertebra or control groups.

5. Conclusions

Chemical shift MRI imaging is a useful technique for evaluating patients with vertebral collapse, whether due to underlying osteoporosis or neoplastic process. Our results suggest that a decrease in signal intensity greater than (35%) on out-of-phase images compared with in-phase images can be used as a cut-off value to differentiate between the osteoporotic and neoplastic vertebral wedging. This finding may have clinical implications and can be applied in daily practice.

References

[7] Zajick Jr DC, Morrison WB, Schweitzer ME, Parellada JA, Carrino JA. Benign and malignant processes: normal values and differentia-

Table 3
Comparison of chemical shift MR imaging in both groups and the percentage of signal reduction on in-phase–out-phase

<table>
<thead>
<tr>
<th>Chemical shift MRI</th>
<th>Osteoporosis (N = 20), mean ± S.D.</th>
<th>Neoplastic (N = 20), mean ± S.D.</th>
<th>P-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-phase</td>
<td>265.97 ± 41.91</td>
<td>266.88 ± 73.18</td>
<td>0.66</td>
<td>NS</td>
</tr>
<tr>
<td>Out-phase</td>
<td>110.78 ± 31.63</td>
<td>219.15 ± 76.1</td>
<td>2.1E−05</td>
<td>Sig.</td>
</tr>
<tr>
<td>Percentage of signal reduction</td>
<td>58.51 ± 9.38</td>
<td>13.55 ± 11.63</td>
<td>2.7E−10</td>
<td>Sig.</td>
</tr>
<tr>
<td>Range of signal reduction (%)</td>
<td>28–26</td>
<td>2–33</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


