MRI assessment of vertebral fractures identified by conventional radiography in osteoporotic patients: a preliminary study

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Purpose

Vertebral fractures are the hallmark of osteoporosis. Approximately 500,000 vertebral fractures occur as a result of osteoporosis every year in Europe. Forty-nine per cent of all fractures occur in the region of vertebral bodies T 11-L3. Eleven per cent occur in the middle part of the thoracic spine column and 5 % occur at the cervical spine. The incidence of osteoporotic vertebral body compression fractures in women older than 50 years is more than one in 100 per year; the rate is three-times higher after the age of 75. Approximately 25 % of women older than 70 years and more than 50 % of women older than 80 years have at least one vertebral fracture (VF). Primary osteoporosis is the main cause of vertebral fractures while secondary osteoporosis and neoplasm account for the remaining 15 %.

The identification of vertebral fractures (VF) has a high prognostic value and it is important for the management of osteoporotic patients, because even with a mild vertebral fracture patients have approximately 5- fold increased risk of further vertebral fractures and 3-fold increased risk of hip fracture. Multiple vertebral fractures are associated with an impaired quality of life and increased mortality rate.

The most widely used method for diagnosing osteoporotic VF is the visual semiquantitative (SQ) of conventional radiographs (XR) described by Genant et al (1)

A vertebral fracture is always a vertebral deformity (wedging, biconcavity or crush), but vertebral deformity is not always a vertebral fracture. It may sometimes be difficult, especially in mild deformities, to discriminate only by radiographs between true vertebral fracture and mild wedge like deformities in the midthoracic region and bowed endplates in the lumbar region due to normal variation in height, developmental abnormalities, degenerative changes, Scheuermann's disease and large Schmorl's nodes, the so-called "short vertebral height" (SVH).

The purpose of our study is to evaluate diagnostic accuracy of magnetic resonance imaging (MRI), compared to XR, in differentiating VF by non-fractures vertebral deformities, and to analyze physical, technical and pathological factors that could cause an underestimation or overestimation of radiological picture in both exams.
Methods and Materials

In this prospective study 152 osteoporotic and osteopenic patients were enrolled.

All patients present a BMD L1-L4 value (inferior to -1.0 SD) with a mean value of -2.6 (range -1.1 - -4.5).

All patients underwent first to a dorsal and lumbar conventional radiographs; X-ray protocol consists in an antero-posteror and a lateral-lateral projections for lumbar and dorsal spine.

Conventional radiology identified 50 asymptomatic patients with at least a vertebral fracture who subsequently underwent to MR. Mean age was 60 years old (range 40-85; 46F, 4M).

MR imaging protocol was obtained by a 3-T MRI unit (GE Discovery MR 750) and based on T1-weighted sequences, T2 weighted sequences, and T2 -weighted fat suppressed sequences, oriented by the columnar axis in a sagittal plane. T2 weighted sequences on axial plane were acquired just in case of disc pathology or neural compression.

Mean time for a MRI study was 10 minutes (range 8-13 minutes) just for sagittal images.

X-rays images were evaluated by an expert radiologist (A) and MRI images were analyzed by three blinded readers (A, B, C). All vertebral fractures were assessed according to Genant semiquantitative method.
Images for this section:

Semiquantitative (SQ) Grading for Vertebral Fractures

0 Normal

0.5 Uncertain or questionable vertebrae

1 Mild Fracture 20-25% anterior middle posterior

2 Moderate Fracture 25-40% anterior middle posterior

3 Severe Fracture > 40% anterior middle posterior

HK Genant, JBMR 1993

Fig. 1: Semiquantitative (SQ) assessment of vertebral fractures by Genant.

Results

Among 650 vertebrae examined, XR detected 130 (20%) VF (75 wedge, 45 biconcave and 10 crush).

MRI identified 145 (22.3%) VF by expert radiologist A (73 wedge, 62 biconcave and 10 crush), 148 (22.7%) by radiologist B (75 wedge, 63 biconcave and 10 crush) and 147 (22.6%) by radiologist C (74 wedge, 63 biconcave and 10 crush).

Table 1

Vertebral fractures detected by conventional XR and by MRI

<table>
<thead>
<tr>
<th></th>
<th>wedging</th>
<th>biconcavity</th>
<th>crush</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>XR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observer A</td>
<td>75</td>
<td>45</td>
<td>10</td>
<td>130 (20%)</td>
</tr>
<tr>
<td>MRI</td>
<td></td>
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<tr>
<td>Observer A</td>
<td>73</td>
<td>62</td>
<td>10</td>
<td>145 (22.6%)</td>
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<tr>
<td>Observer B</td>
<td>75</td>
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<td>10</td>
<td>148 (22.7%)</td>
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<tr>
<td>Observer C</td>
<td>74</td>
<td>63</td>
<td>10</td>
<td>147 (22.6%)</td>
</tr>
</tbody>
</table>

There was a fair agreement between the two techniques and lower diagnostic performance of XR compared to MRI (k-score = 0.572; sensitivity 88%, specificity 100%, PPV 100%, NPV: 0.97%). Inter-observer agreement among the three radiologists was good (A vs B; k=0.82; A vs C k=0.88; B vs C k=0.91).
Fig. 2: Both XR and MRI show a moderate wedge fracture on T12 and a mild wedge fracture on T11.

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**Fig. 3:** Both XR and MRI show moderate concave fractures on T7, T8 and T10.

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Fig. 4: In this case XR shows a mild wedge fracture on T5 and a severe wedge fracture on T12. MR confirms fractures on T5 and T12 and detects multiple wedge fractures affecting segment from C7 to T3, and T9. This misdiagnosis, at XR examination, is due to the overlapping of ribs and soft structures.

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Fig. 5: XR examination reveals mild wedge fractures on T12 and L2. On L3 a focal alteration of the upper surface of the body was noticed, and interpreted as a large Schmorl's node. MR scan confirms both wedge fractures and T2-weighted fat suppressed images reveal a monoconcave fracture affecting the upper surface of L3, surrounded by an area of intraspongious edema. A new MRI scan, performed 3 months later, shows partial resolution of L3 edema and an increase of wedging on T12 and L2 (grade moderate).

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Fig. 6: In this patient XR diagnoses a Schmorl's node at T12 level confirmed by MRI. MRI also detects a mild concave fracture on T10 and T11, not recognizable on XR examination.

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Conclusion

MRI identified more VF if compared to XR in particular biconcave type, most of them localized at the upper thoracic level (from T4 to T6), that was sometimes unreadable by XR. Others undetected VF by XR were recognized at the lower lumbar and lower thoracic spines.

In fact the conventional radiography commonly used in clinical practice as a reference standard, has some well-known limitations due to the X-ray cone beam, which causes geometric distortion of vertebrae located at the extremities of the scans (parallax effect). Furthermore, in the radiographs performed in lateral decubitus, the vertebrae of upper thoracic level (T1-T5) are not always valuable for overlapping of ribs and soft structures. Finally, in cases of moderate-severe scoliosis, vertebrae close to the rotation fulcra could have a biconcavity appearance.

These technical limits of conventional radiography can cause an overestimation or an underestimation in terms of grade or presence of fractures.

The concept of misdiagnose of a vertebral fracture gets more importance, if we consider that the presence of at least a single fracture increases 5-fold risk of further VF, resulting in an increased mobility and mortality.

Therefore, if the conventional XR undiagnosed VF in osteoporotic patients, MRI could be a valid supplementary method in the detection of VF visualizing more precisely the entire spine. It can directly acquire images in any plane de novo and has the potential to obtain informations about vertebral morphology and vertebral bone alteration, not readily available with conventional XR. Since its first clinical bone applications in 1977 improvements in coil technology, pulse sequencing, analytical techniques, and gantry hardware have advanced the usefulness of MRI in all aspects of bone imaging, including osteoporosis research.

Furthemore the higher SNR, obtained with a 3-T MRI unit, can be used to either increase spatial resolution or decrease acquisition time; the possibility of time-reduction, without significant image quality loss, represents an important advantage in case of old or non-compliant patients.

The use of fat suppressed sequences, especially T2-weighted, allows the detection of intraspongiosus edema that can be an early sign of some future morphology changes, as a fracture, or represents the bone reaction to an acute stress.

Moreover intraspongiosus edema, in case of vertebral fractures, can suggest their recent onset.
In conclusion, considering these preliminary data, we suggest complementary use of MRI in patients at high risk of osteoporotic VF with negative conventional XR to avoid the VF domino effect.
References

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