

Review

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Review

Vertebral Fractures in the Elderly: Radiologic Patterns and Red Flag Signs

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Abstract

Background: Vertebral fractures are among the most common and clinically important outcomes of osteoporosis in older adults. They significantly contribute to pain, functional limitations, and a decline in quality of life. A significant proportion of these fractures remain clinically silent or present with vague symptoms, which often delays diagnosis. As a result, imaging plays a central role in detection. Distinguishing uncomplicated osteoporotic fractures from those caused by malignancy or infection is essential, as missed or delayed recognition may lead to inappropriate management and avoidable neurological complications. **Aim:** This review aims to outline the typical radiological patterns of vertebral fractures in the elderly and to highlight key imaging “red flag” features that raise suspicion of secondary pathology or structural instability. **Methods:** A narrative review of the literature was conducted, drawing on published studies that address the epidemiology, imaging appearances, and management of vertebral fractures. The discussion focuses on the role of PET/CT, computed tomography, magnetic resonance imaging, nuclear medicine, and PET/CT, with particular attention to imaging features that help distinguish benign osteoporotic fractures from pathological fractures. **Results:** Plain radiographs are useful for identifying vertebral deformity but have limited value in differentiating acute from chronic fractures. Computed tomography allows a more accurate assessment of cortical disruption, fracture morphology, and retropulsed fragments. Magnetic resonance imaging remains the reference standard for characterising vertebral fractures, as marrow signal changes, soft-tissue components, and posterior element involvement reliably separate benign from malignant causes. Nuclear medicine studies assist in assessing fracture chronicity, while PET/CT helps differentiate metastatic disease from benign lesions. Imaging features that should prompt concern include paraspinal soft-tissue masses, involvement of posterior elements, multiple contiguous vertebral lesions, and a convex posterior vertebral body margin. **Conclusions:** Careful recognition of typical imaging patterns and associated red flag signs is fundamental in differentiating benign osteoporotic vertebral fractures from secondary causes. Accurate and timely diagnosis helps in appropriate management, minimises neurological complications, and ultimately improves outcomes in elderly patients.

Keywords: vertebral compression fractures; osteoporosis; radiologic patterns; magnetic resonance imaging; red flag signs

Introduction

Vertebral fractures are a frequent complication of osteoporosis, characterised by reduced bone density in older adults, often leading to chronic back pain, reduced mobility, and a noticeable drop in quality of life. [1,2] Because symptoms can be vague or occur without a clear injury, many of these fractures are often unnoticed initially. [2] With a gradual global increase of the elderly population, radiologists frequently diagnose these fractures incidentally and as a cause of acute back pain. [3] Although most osteoporotic fractures are benign, a few may mask underlying malignancies, infections, or other secondary causes. Therefore, a detailed understanding of radiologic patterns and

the timely identification of “red flag” signs is crucial in accurate diagnosis, optimal management and minimising further complications. [4] This article highlights radiologic patterns, clinical red flag signs, and advances in the screening of vertebral fractures.

Epidemiology and Clinical Context

In Sri Lanka’s urban centres, studies show that it affects roughly 27% of women and 7% of men over the age of 50. [5] The global picture reveals an even more striking consequence of this condition: by age 70, nearly a quarter of women and 12% of men will experience a vertebral compression fracture due to weakened bones. [6]

What makes osteoporosis so deceptive is that many fractures are asymptomatic and discovered incidentally on chest or abdominal imaging. Patients may seek medical advice when they experience sudden-onset back pain, loss of height, or progressive kyphosis. Osteoporotic bone fractures can occur with minimal trauma, such as falling from a standing height. When pain is disproportionate or accompanied by systemic symptoms, “red flag” causes such as malignancy or infection must be excluded. [4]

Understanding the Cause

Osteoporosis does not have a single cause. It is helpful to understand its two main categories: Primary Osteoporosis, the most common form related to the natural ageing process, and Secondary Osteoporosis, which is caused by specific diseases or medications. [7]

Primary Osteoporosis

- Postmenopausal osteoporosis (Type I)-In women, the sharp decline in estrogen during menopause accelerates bone loss.
- Senile osteoporosis (Type II) - This affects both men and women, typically after the age of 70.

Secondary Osteoporosis

- Long-term corticosteroid use
- Hyperparathyroidism
- Hyperthyroidism
- Diabetes
- Rheumatoid arthritis.
- Chronic kidney or liver disease.
- Multiple myeloma
- Prolonged immobility or lack of weight-bearing exercise.

Imaging Modalities

DEXA (Dual-Energy X-Ray Absorptiometry) Scan

The DEXA scan is recognised as the gold standard for evaluating bone health. Its primary goal is to detect low bone mineral density (BMD) before fractures occur, enabling proactive management and treatment. This low-radiation test provides precise measurements of BMD at key weight-bearing sites, most commonly the lumbar spine and proximal femur. DEXA scans report two main scores: the T-score and the Z-score. [8–11]

T-Score: Key Indicator for Adults

For postmenopausal women and men over 50, the T-score is the primary diagnostic measure for assessing bone density. The World Health Organisation (WHO) has defined the following thresholds:

- **Normal Bone Density:** T-score ≥ -1.0
- **Osteopenia (Low Bone Mass):** T-score between -1.0 and -2.5
- **Osteoporosis:** T-score < -2.5

Beyond simply categorising bone health, the T-score provides a quantitative link to fracture risk: each drop of one standard deviation in the T-score corresponds to a substantial increase in fracture likelihood. [8–11]

Z-Score: Age-Specific Assessment

In younger adults, premenopausal women, and children, the Z-score is more relevant. It shows how a bone density compares with what is typical for someone of the same age and sex. If the Z-score is -2.0 or lower, it is considered unusually low for their age, and further investigation may be needed to identify possible underlying causes of bone loss. [8–11]

Plain Radiography

Lateral spine X-ray is the first-line imaging modality for suspected vertebral fractures. X-rays can identify loss of vertebral height and deformity, although early or subtle fractures may be missed. **The Genant semiquantitative method** is a common method for grading vertebral deformities as mild (20–25% height loss), moderate (25–40%), or severe (>40% height loss). (Figure 1). Despite its utility, plain radiography has limitations as it cannot reliably distinguish between acute and chronic fractures or between benign and malignant causes. [10]

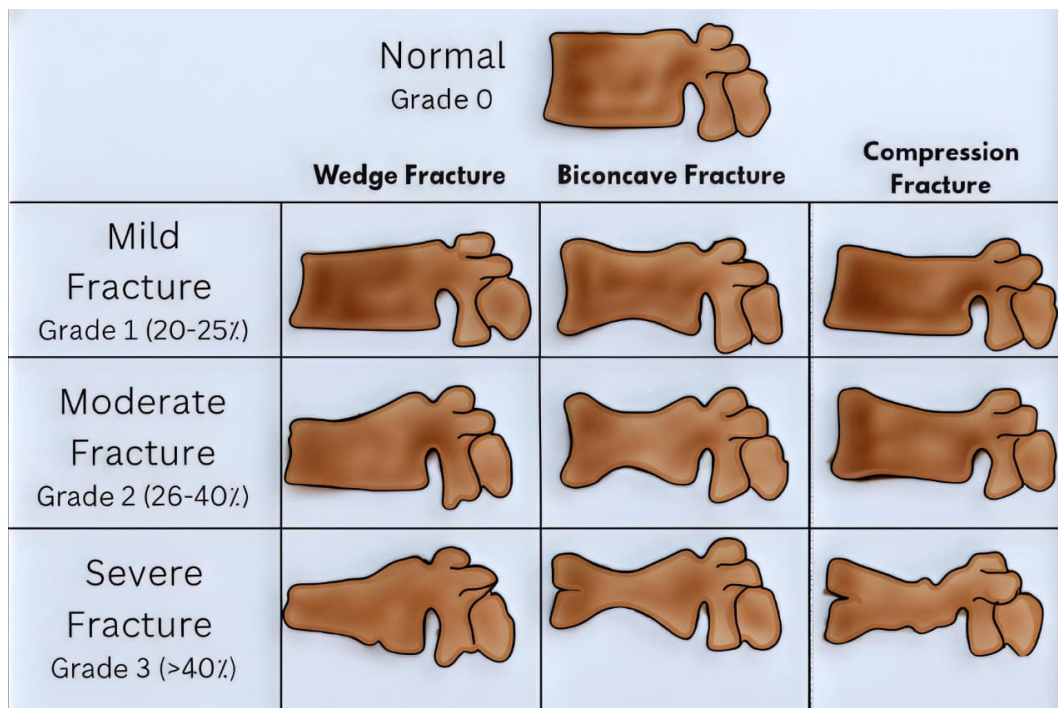


Figure 1. The Genant semiquantitative method is a common method for grading vertebral deformities as mild, moderate, or severe.

Computed Tomography (CT)

CT offers excellent spatial resolution for evaluating fracture morphology, cortical breaches, retropulsed bone fragments, posterior element involvement, and neural canal involvement. In osteoporotic compression fractures, CT typically reveals anterior wedge-shaped vertebral bodies with intact posterior elements and absence of soft-tissue mass. Conversely, malignant fractures may

show lytic lesions, cortical destruction, irregular endplates, and associated paraspinal or epidural soft-tissue masses (**Figure 2**). CT is also invaluable in surgical planning and evaluating complex burst or unstable fractures. [9,11]



Figure 2. Sagittal CT image of the thoracic spine (bone window) demonstrates markedly reduced bone mineral density with multiple lytic vertebral lesions. There are associated multiple severe compression fractures involving the upper thoracic vertebrae, resulting in loss of vertebral body height and kyphotic deformity, features suspicious for an underlying pathological process.

Magnetic Resonance Imaging (MRI)

MRI remains the gold standard for differentiating benign osteoporotic fractures from pathologic fractures due to malignancy or infection.

T1W images show marrow with low signal (hypointense) in acute fractures, while STIR or fat-saturated T2 sequences demonstrate marrow oedema (hyperintense), confirming the acuity. (**Figure 3**) Chronic fractures often lack marrow oedema and may exhibit fatty replacement.

Benign osteoporotic fractures typically exhibit band-like low signal intensity on T1 and T2 images along the endplate, with spared posterior elements and normal adjacent discs. Malignant fractures, in contrast, exhibit diffuse marrow replacement, convex posterior vertebral borders, epidural or paraspinal soft-tissue components, and involvement of the posterior elements or multiple contiguous vertebrae.

Diffusion-weighted imaging (DWI) and contrast-enhanced MRI further aid in characterisation: restricted diffusion and early enhancement suggest malignancy. At the same time, benign fractures show variable enhancement patterns. [11,12]

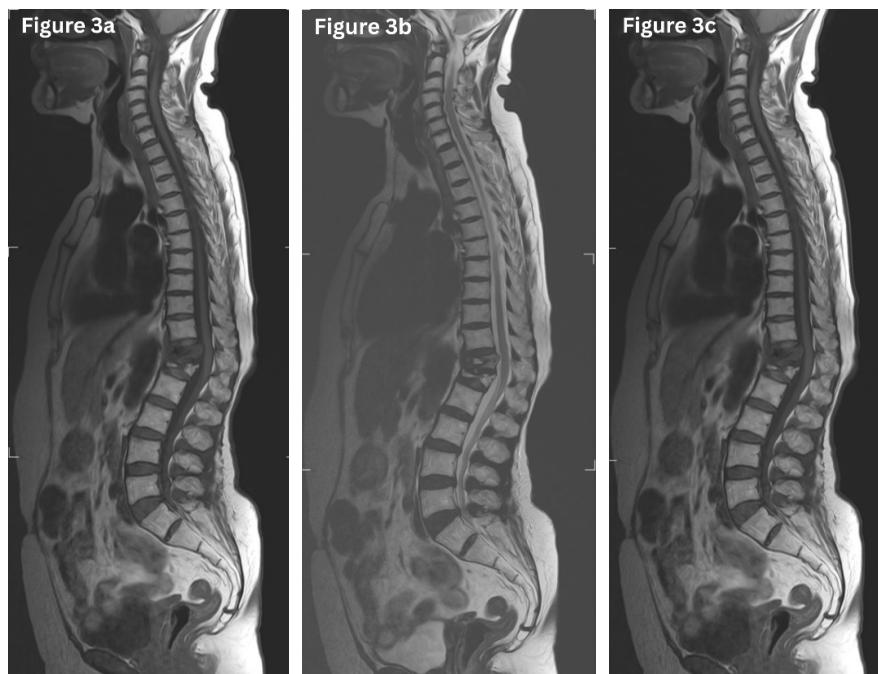


Figure 3. a-c. Sagittal MRI of the thoracolumbar spine demonstrates significant compression fractures involving the T12 and L1 vertebral bodies. Retropulsion of the T12 vertebral body is noted, resulting in mild compression of the lower spinal cord. The affected vertebrae exhibit low signal intensity on T1-weighted images (Figure 3a), accompanied by high signal intensity on T2-weighted images (Figure 3b) and STIR sequences (Figure 3c), consistent with acute vertebral compression fractures.

Nuclear Medicine and PET Imaging

Bone scintigraphy (^{99m}Tc -MDP) can help detect multiple fractures and assess chronicity when MRI is contraindicated. However, increased uptake may persist for months after an acute event. ^{18}F -FDG PET/CT can differentiate between metastatic and benign fractures, as malignant lesions typically show higher standardised uptake values. [11,12]

Morphological Classification of Vertebral Compression Fractures

1. Wedge compression fracture

- The most common pattern involves anterior height loss with preservation of the posterior wall.
- Usually seen in the thoracolumbar junction (T12–L2).
- Suggests osteoporosis when occurring with minimal trauma.

2. Biconcave (Codfish) fracture

- Central endplate depression gives a “fish vertebra” appearance.
- Common in metabolic bone diseases such as osteoporosis or osteomalacia.

3. Crush fracture

- Uniform collapse of the vertebral body height.
- It can cause severe kyphotic deformity.
- It may mimic pathological fractures if extensive.

4. Burst fracture

- Results from axial loading with involvement of both anterior and posterior walls.
- Retropulsed fragments may impinge on the spinal canal, which is a red flag requiring urgent assessment.
- Often seen in trauma or advanced osteoporosis.

Red Flag Signs Suggesting Pathologic or Complicated Fracture

Radiologists must recognise imaging features that raise suspicion for secondary causes or instability. Evidence-supported red flags include:

Red Flag Feature	Possible Cause
Involvement of posterior elements	Malignancy or infection
Paraspinal or epidural soft-tissue mass	Metastasis, myeloma, abscess
Convex posterior border of the vertebral body	Malignant infiltration
Irregular endplate destruction	Infection or neoplasm
Multiple contiguous vertebral involvement	Metastatic disease, myeloma
Preservation of the intervertebral disc with adjacent bone destruction	Neoplasm
Disc space narrowing with endplate erosions	Spondylodiscitis
Retropulsed bony fragments or canal compromise	Unstable fracture
Persistent or worsening pain beyond 6 weeks	Possible secondary pathology

Although the diagnostic accuracy of red flags is variable, a combination of these signs substantially increases their predictive value for identifying pathologic or complicated fractures. This warrants a more intensive diagnostic workup, including advanced imaging, to guide subsequent management. [13]

Management Implications

Osteoporosis management in osteoporotic patients is important in minimising future fractures. This includes Calcium and Vitamin D supplementation, Bisphosphonates, Denosumab and Teriparatide. Management of vertebral fractures in older people primarily involves conservative treatment focused on pain relief, functional restoration, and prevention of future fractures. Correct identification of the fracture pattern and underlying aetiology guides therapy.

- **Benign osteoporotic fractures** are managed conservatively with short-term bed rest, with analgesia for pain relief, and gradual mobilisation with physiotherapy could be focused initially.
- **Vertebroplasty or kyphoplasty** may be considered for persistent pain with stable fractures.
- **Pathologic fractures** due to malignancy or infection warrant biopsy and targeted therapy.
- **Unstable fractures** with neurological compromise require surgical stabilisation.

MRI follow-up after 6–12 weeks can document fracture healing and resolution of marrow oedema, helping to avoid unnecessary repeat interventions. [14]

Prevention and Prognosis

Preventing further fractures is one of the most important goals in managing osteoporosis. Once a person experiences a vertebral fracture, their risk of having another increases by nearly five times. This highlights the importance of early detection and prompt treatment. Management includes calcium and vitamin D supplements, together with medications such as bisphosphonates, denosumab, or teriparatide. Regular weight-bearing exercises and a practical approach to minimise the risk of falls are also essential parts of care. While many simple fractures heal well with conservative treatment, missing a malignant or unstable fracture can lead to lasting nerve damage or persistent pain. [14]

Conclusions

In elderly patients, vertebral fractures should never be ignored as casual findings on imaging. They often indicate weakened bones or, in some cases, a more serious underlying condition. Radiologists play a crucial role in identifying these fractures early and distinguishing between different causes. Recognising typical imaging features and being alerted to warning signs helps ensure timely treatment, reduces complications, and supports better mobility, independence, and quality of life in later stages of life.

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Availability of data and materials: Acquired DICOM medical images during the current review are available from the corresponding author upon reasonable request. The subject's identifying information was removed from the radiology images.

Conflicts of Interest: The authors declare no conflict of interest.

Ethical Approval: Ethical approval was not considered, as our work is a narrative review. However, we have secured informed consent to publish radiological images from each patient (Image numbers: Figures 2 and 3). Figure 1 was created by WNH. Additionally, we have intentionally removed identifying information from the radiology images. Consent was obtained in the local and English languages, and fully completed consent forms are available upon request.

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