Imaging in Osteoporosis Diagnosis and Management.

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Abstract

Osteoporosis is a prevalent metabolic bone disease in the western world, resulting in low trauma fractures and increased morbidity and mortality rates among sufferers. The article describes the common imaging required in the diagnosis and management of osteoporosis. It is important to include imaging within the patient pathway where vertebral fractures are suspected and to use additional imaging modalities such as MRI to aid differential diagnosis where the cause of the fracture is unclear. Radiographers and radiologists reporting imaging examinations may be the first clinicians to suspect the presence of osteoporosis and have a role in helping to ensure that these patients do not get missed so that appropriate treatment can be started. Ideally there should be locally-agreed pathways whereby such patients are automatically referred to the fracture liaison service, regardless of the original requester of the imaging investigation.

Key words: Osteoporosis, Imaging, Fracture, Diagnosis
Introduction

Osteoporosis is a common metabolic bone disease in the elderly population within the UK and is characterised by reduced bone density and micro-architectural deterioration of bone. This results in an increased risk of fracture\(^1\) with one in two women and one in five men over the age of 50 sustaining a fracture, most of which are attributable to osteoporosis\(^2\). Osteoporosis is becoming an increasing public health issue in the UK, with the incidence predicted to increase by almost a fifth by 2020 in line with the aging population\(^3\). Therefore, appropriate diagnosis, therapeutic intervention and monitoring is required to reduce the burden of osteoporosis-related fractures, including appropriate imaging to facilitate accurate diagnosis. This paper will discuss the use of imaging in the differential diagnosis and monitoring of osteoporosis in an elderly population.

Diagnosis

Dual energy x-ray absorptiometry (DXA) currently provides the most widely accepted method for the assessment of osteoporosis\(^4\), with the world health organisation criteria for the diagnosis of osteoporosis being used as standard in postmenopausal women\(^5\). Screening for osteoporosis in the UK is not supported at present\(^6\) and therefore those at highest risk should be identified through clinical risk factors. The FRAX tool can be used to identify those who require a DXA referral and also predicts fracture risk from the number of clinical risk factors in normal and obese female populations\(^7,\,8\). Falls history should also be considered alongside bone mineral density and clinical risk factors when deciding on therapeutic intervention, since it provides a further independent risk factor for fracture\(^9\).

Patients presenting with a low trauma fracture or those who have notable x-ray osteopenia should also be referred for a DXA scan, with the former group attending the fracture liaison service if available. X-ray osteopenia is demonstrated in figure one and can be noted by reduced cortical thickness with an associated appearance of reduced density and more prominent trabeculation being visualised on a radiograph, frequently providing less contrast between the bone and soft tissues than when compared to radiographs of normal density bone\(^10\). Whilst osteoporosis may be suspected from these plain radiographic findings this is not a reliable way of making the diagnosis and plain film radiography is not indicated purely to assess for bone density. On the other hand, plain films may be helpful in suggesting the diagnosis when there is new onset of pain and suspected osteoporotic vertebral fracture.
While DXA is the most commonly used tool, it has a number of limitations, including the spine measurements being confounded by degenerative changes and aortic calcification in elderly populations, along with difficulty positioning the hip where patients are unable to hold the required position well\textsuperscript{11}. Obesity results in inaccuracies and poor precision in the spine and hip, with the most marked of these being at the spine due to tissue inhomogeneity\textsuperscript{12}. A fat paniculus can result in inaccuracies at the hip and retraction of this is advised where possible\textsuperscript{11}. Furthermore, large weight changes in either direction result in inaccuracies in measuring longitudinal changes in the hip and spine\textsuperscript{13, 14}. Despite these confounders, DXA is still a valuable tool in much of the elderly population.

**Vertebral fracture assessment**

Dual x-ray absorptiometry scanners can also be utilised for vertebral fracture assessment (VFA), as demonstrated in figure 2. VFA provides a lateral image of T4 to L4, and has a significantly reduced dose compared to a thoraco-lumbar projection radiography series\textsuperscript{15}. It has been reported to have a high degree of accuracy for diagnosing fracture and in practice can increase the identification of vertebral fractures and altered patient management in those with unknown fractures\textsuperscript{16, 17}. The presence of a vertebral fracture can lead to pain, deformity and loss of function, but importantly is also a strong predictor of future fracture\textsuperscript{18}. In 2000, it was estimated that less than 30% of vertebral fractures are diagnosed, thus improved strategies to identify those with vertebral fractures is of utmost importance\textsuperscript{19}. Using VFA in practice has been demonstrated to increase the number of patients diagnosed with osteoporosis and requiring therapeutic intervention\textsuperscript{20, 21}.

If a vertebral fracture is identified on a VFA scan, the international society for clinical densitometry (ISCD) recommends that routine x-rays are not required to confirm the fracture, but may be required to confirm an equivocal fracture, to differentiate between non-fracture deformities such as Scheuermanns’ disease or degenerative changes, or to examine for another pathology causing the fracture, for example Paget’s disease of bone or malignancy\textsuperscript{22}. Further imaging may be required where other underlying pathology is suspected and magnetic resonance imaging (MRI), CT, Nuclear Medicine or PET-CT may be used depending on the pathology suspected. MRI and PET-CT in combination have been demonstrated to have high sensitivity and specificity for benign and malignant lesions in the spine, with 100% accuracy in the former\textsuperscript{23}. Figures 3a and 3b demonstrate a vertebral fracture resulting from metastatic disease.

Painful vertebral fractures in which the patient continues to have pain despite optimal pain management\textsuperscript{24}, should be investigated using clinical examination and or imaging to confirm the pain is at the site of the fracture. Magnetic resonance imaging can be particularly useful
if considering a vertebroplasty or kyphoplasty. Figure 4 demonstrates a recent osteoporotic fracture which may be amenable to vertebroplasty. Patients with osteoporosis suffering from low back and pelvis pain should have sacral insufficiency or stress fractures considered as part of their differential diagnosis. These occasionally also occur in the final trimester of pregnancy and postpartum in younger women. Plain film radiographs are frequently inconclusive in this condition, while CT or MRI provide better sensitivity and specificity, with MRI being considered the current gold standard.

*Imaging of other osteoporotic fractures*

Osteoporosis can lead to fractures anywhere in the skeletal system, although fractures of the wrist, hip and vertebrae are the most commonly seen. Plain film radiography is usually the first line method for imaging these fractures and in many cases is sufficient to make a diagnosis. However, in some patients, occult fractures may be present. These are of particular importance in the hip, where identifying the fracture quickly to ensure the patient reaches theatre on the day of or following admission is of utmost importance. Occult fractures of the hip (figure 5) may be present when the patient presents clinically with the signs and symptoms of a hip fracture, but the radiographic images fail to demonstrate this. In this case the ideal pathway providing the greatest diagnostic accuracy is to perform an MRI scan, where the bone marrow oedema associated with the occult fracture can confirm its presence. In patients who are not suitable for MRI, or where MRI is not available, computed tomography (CT) can be used as an alternative, though has a marginally poorer accuracy.

*Differential diagnosis*

The presence of apparent osteoporosis on a DXA measurement, with or without fracture, may not provide the definitive diagnosis. Vitamin D deficiency is becoming increasingly prevalent among the elderly population within the UK and therefore osteomalacia should be ruled out by blood tests, particularly in those who are immobile and do not go outside often. There are occasionally some findings in osteomalacia which are not seen in osteoporosis. A "Looser's zone" or pseudofracture, may be seen in osteomalacia along with reports of bone pain and muscle weakness, which are not typical symptoms of osteoporosis.
Multiple myeloma can cause lytic lesions, which improve with chemotherapy but the x-ray appearance may also be one of diffuse osteopenia, mimicking osteoporosis. There should be a low index of suspicion for this condition and patients with suspected Multiple Myeloma may be screened by blood tests looking for anaemia, abnormal protein levels and raised plasma viscosity and even further assessment of urine for Bence Jones protein and plasma electrophoresis where diagnosis is strongly suspected. Finally, occasional anatomical anomalies are visualised on DXA scans which may or may not impact on the BMD results. If these are unexplained, then further imaging may be required to investigate these.

**Longitudinal monitoring**

A diagnosis of osteoporosis requires the consideration of therapeutic intervention in line with national and local guidelines and in line with clinical decision making in relation to the clinical history of the patient. Longitudinal scans can be useful in a population with low bone density, where therapeutic intervention would not be indicated, but who may be at risk of developing osteoporosis in the future. Once a patient is put onto a pharmacological intervention for osteoporosis, monitoring of their treatment response needs to be considered. The use of bisphosphonates, the most common first line treatment for osteoporosis is known to be linked with poor adherence and compliance. Treatment monitoring therefore can be of benefit to check the compliance and adherence of the patient. However, the use of DXA in treatment monitoring is often sub-optimal. The time intervals required are generally between 18 to 24 months and in obese patients may be even greater. Biochemical markers of bone turnover are an appropriate alternative where available and can detect treatment response much more rapidly than DXA, with a reliable result just three months post commencing treatment. Monitoring of BMD five to ten years post commencing treatment is of particular use when considering a drug treatment holiday for patients on bisphosphonates to prevent the over suppression of bone turnover. Further monitoring may be required during the treatment holiday when an increase in bone turnover markers and a reduction in BMD may signal the requirement to recommence treatment.

Bisphosphonates have been demonstrated to be effective at increasing BMD and reducing fractures by approximately 50% over 2 years of use. However, as the longevity of bisphosphonates has increased, adverse events in long-term users, generally of greater than five years have been reported. Atypical fractures of the femora (figure 6) in men and women have been reported in a number of studies. These fractures share a common
appearance, with periosteal thickening as often seen in stress fractures. The fractures also tend to be transverse and in the upper third of the femur\textsuperscript{41, 42}. Plain film radiography is the most common method for diagnosing these fractures and additional imaging is rarely required; the important thing is for radiologists and physicians to be aware of the plain film findings and to suspect the condition when patients on bisphosphonate therapy present with new hip or thigh pain. If there is doubt on the plain films MRI may be helpful.

Osteonecrosis of the jaw (ONJ) is a rare, but notable complication of those on long term and especially high dose bisphosphonates, such as those with metastatic bone disease\textsuperscript{43}. Imaging for this is required to ascertain the extent and differentiate from metastatic disease. Nuclear medicine scintigraphy provides the ability for early diagnosis and other imaging may include dental radiographs, orthopantomographs (OPG’s), MRI and CT to investigate the extent and assist in differential diagnosis of ONJ\textsuperscript{44}.

Conclusion

In conclusion, imaging plays an integral role in the diagnosis and management of osteoporosis, osteoporotic fractures and the complications associated with bisphosphonate treatment. It is important to include imaging within the patient pathway where vertebral fractures are suspected and to use additional imaging modalities such as MRI to aid differential diagnosis where the cause of the fracture is unclear. Radiographers and radiologists reporting imaging examinations may be the first clinicians to suspect the presence of osteoporosis and have a role in helping to ensure that these patients do not get missed so that appropriate treatment can be started. Ideally there should be locally-agreed pathways whereby such patients are automatically referred to the fracture liaison service, regardless of the original requester of the imaging investigation.
References


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Figure 1: Plain film of typical osteoporotic vertebral fracture and demonstrating x-ray osteopenia
Figure 2: GE Lunar Prodigy dual energy lateral vertebral assessment scan, utilising morphometric software to indicate fracture presence and grade.
Figure 3: MRI of vertebral fracture from metastasis
Figure 3b: MRI of vertebral fracture from metastasis
Figure 4: MRI showing recent OP fracture (and old fractures) which may be amenable to vertebroplasty
Figure 5: MRI showing occult femoral neck fracture
Figure 6: Plain film of atypical femoral fracture