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Radiology of Osteoporosis

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Abstract

The radiologist has a number of roles not only in diagnosing but also in treating osteoporosis. Radiologists diagnose fragility fractures with all imaging modalities, which includes magnetic resonance imaging (MRI) demonstrating radiologically occult insufficiency fractures, but also lateral chest radiographs showing asymptomatic vertebral fractures. In particular MRI fragility fractures may have a nonspecific appearance and the radiologists needs to be familiar with the typical locations and findings, to differentiate these fractures from neoplastic lesions. It should be noted that radiologists do not simply need to diagnose fractures related to osteoporosis but also to diagnose those fractures which are complications of osteoporosis related pharmacotherapy. In addition to using standard radiological techniques radiologists also use dual-energy x-ray absorptiometry (DXA) and quantitative computed tomography (QCT) to quantitatively assess bone mineral density for diagnosing osteoporosis or osteopenia as well as to monitor therapy. DXA measurements of the femoral neck are also used to calculate osteoporotic fracture risk based on the Fracture Risk Assessment Tool (FRAX) score, which is universally available. Some of the new technologies such as high-resolution peripheral computed tomography (HR-pQCT) and MR spectroscopy allow assessment of bone architecture and bone marrow composition to characterize fracture risk. Finally radiologists are also involved in the therapy of osteoporotic fractures by using vertebroplasty, kyphoplasty, and sacroplasty. This review article will focus on standard techniques and new concepts in diagnosing and managing osteoporosis.

Résumé

Le rôle du radiologiste ne se limite pas au diagnostic de l'ostéoporose; il intervient également dans le traitement de cette maladie. Le radiologiste émet des diagnostics de fracture de fragilisation avec toutes les modalités d'imagerie, y compris par imagerie par résonance magnétique (IRM) qui révèle la présence de fractures par insuffisance invisibles par radiographie, ainsi que sur l'incidence de profil lors d'une radiographie du thorax qui révèle la présence de fractures vertébrales asymptomatiques. Comme les fractures de fragilisations détectées par IRM ont parfois une présentation non spécifique, le radiologiste doit connaître leur emplacement et leurs résultats typiques afin de les différencier des lésions néoplastiques. Il importe de souligner que le radiologiste ne se limite pas au diagnostic des fractures liées à l'ostéoporose. Il doit également diagnostiquer les fractures qui découlent de complications liées à la pharmacothérapie de l'ostéoporose. Outre les techniques radiologiques normalisées, le radiologue a recours à l'absorptiométrie biénergétique à rayons (DXA) et à la tomodensitométrie quantitative (QCT) pour évaluer quantitativement l'ostéodensitométrie aux fins de diagnostic de l'ostéoporose ou de l'ostéopénie ainsi que de suivi du traitement. La mesure par DXA du col du fémur est également utilisée pour calculer le risque de fracture ostéoporotique à l'aide du système universel de cote FRAX. De nouvelles technologies, comme la tomodensitométrie quantitative périphérique haute résolution (HR-pQCT) et la spectroscopie par résonance magnétique (SRM), permettent d'évaluer l'architecture osseuse et la composition de la moelle osseuse afin de caractériser le risque de fracture. Enfin, le radiologiste participe également au traitement des fractures ostéoporotiques par vertébroplastie, spondyloplastie expansive et sacroplastie. Le présent article de synthèse porte sur les techniques normalisées et les nouvelles méthodes de diagnostic et de prise en charge de l'ostéoporose.

Key Words: Osteoporosis; Bone mineral density; Dual-energy x-ray absorptiometry; Insufficiency fractures; Vertebroplasty; Kyphoplasty; Sacroplasty

An important driver that motivates us to diagnose osteoporosis at early stages and to evaluate the risk of fracture is the availability of effective therapies that can prevent osteoporotic fractures. It is critical, however, that only those at risk or with prevalent osteoporotic fractures are treated as therapies are expensive and side effects have been associated

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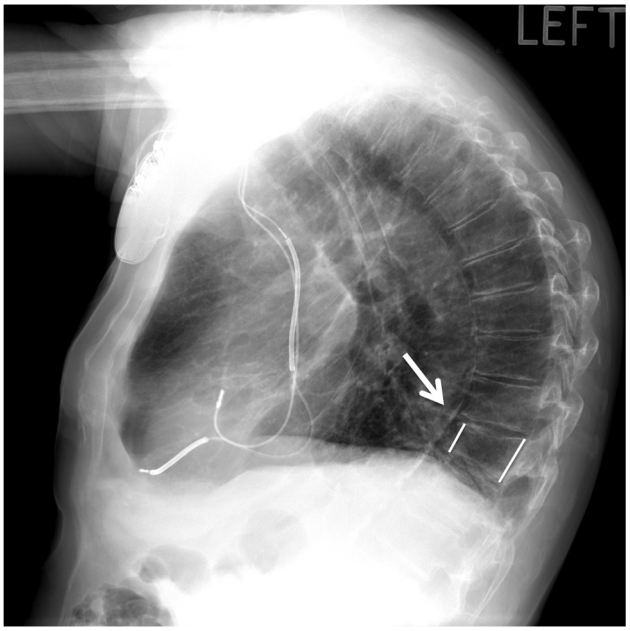

Figure 1. Lateral chest radiograph of a 71-year-old man with a grade 2 osteoporotic vertebral fracture at T11 with 35% height loss measured by dividing the height of the posterior border of the vertebral body by the anterior height (white lines). These fractures can be easily missed but are clinically very significant as they may be an indication for medical treatment of osteoporosis.

with these therapies, such as atypical subtrochanteric fractures with bisphosphonates [1,2]. Patients who already have osteoporotic fractures are clearly candidates for therapy but not always are fractures symptomatic or correctly diagnosed by the radiologist. Also, the referring physician may not consider these incidentally noted fractures as an indication for treatment. Radiologists therefore have an important role in guiding management, but not always are they aware of the significance of the findings and adequate training is essential [3].

Interpretation of standard imaging biomarkers such as dual energy x-ray absorptiometry (DXA) and quantitative computed tomography (QCT) is more straightforward but training is also critical to provide treatment recommendations and interpret the impact of therapy. DXA measurements of the proximal femur should include Fracture Risk Assessment Tool (FRAX) fracture risk assessment to improve identification of patients at risk for fracture with osteopenic bone mineral density (BMD) [4]. Limitations of BMD measurements are well known and have driven the development of novel imaging biomarkers focusing on bone quality such as high-resolution peripheral QCT (HR-pQCT).

In addition to identifying and guiding management of patients at risk for fractures as well as monitoring therapy radiologists are also directly involved in treatment by performing vertebroplasties, kyphoplasties, and sacroplasties. These are a team approach and require concomitant treatment and radiologists need to be an active part of the treatment team [5].

The scope of this article is: 1) to highlight the importance of osteoporotic fractures and typical imaging findings using different modalities; 2) to review standard and novel quantitative imaging modalities to measure bone mineral density and bone quality; and 3) to discuss therapeutic interventions and their role in osteoporotic fractures.

Background and Epidemiology

The percentage of older patients is steadily increasing and the yearly number of fragility fractures related to deficient bone mass and quality will increase substantially with continued ageing of the population [6]. Approximately 50% of women and 20% of men older than 50 years of age will have a fragility fracture in their remaining lifetime in Caucasian populations [7] with potentially devastating results. Of the individuals who suffer hip fractures 20% will die within the next year and 20% will require permanent nursing home care [7].

Patients with vertebral fractures have less severe complications, but vertebral fractures are much more frequent and only 30% of the vertebral fractures come to clinical attention [6]. Those that come to clinical attention are associated with substantial disability from pain and increased thoracic kyphosis. In addition the presence of 1 vertebral fracture leads to a 10-fold increase in risk of subsequent vertebral fractures [8]; diagnosis and treatment of vertebral fractures is therefore critical. While hip, vertebral, and wrist fractures are the most frequent fractures associated with osteoporosis, the effect of osteoporosis on the skeleton is systemic and there is an increased risk of almost all types of fractures in patients with deficient bone mass and quality.

Diagnosing Fragility Fractures

Radiologists need not only be familiar with correctly interpreting signs of fragility fractures but also using all available imaging modalities for this purpose. In 2000 a study received major public attention that raised significant concern about vertebral fractures being inadequately reported by radiologists [9]. In this study Gehlbach et al [9] reviewed the posterior-anterior and lateral chest radiographs of 934 women aged 60 years and older, who had been admitted to hospital. Radiology reports mentioned only 50% of 132 moderate and severe vertebral fractures found in these women and only 17 patients had a discharge diagnosis of vertebral fracture. All of these 132 patients were candidates for treatment but only a small percentage eventually received pharmacotherapy. Subsequently other studies showed similar findings [10,11] and the Vertebral Fracture Initiative by the International Osteoporosis Foundation and the European Society of Skeletal Radiology was launched to raise awareness and to train radiologists in diagnosing fractures. Figure 1 shows a typical osteoporotic fracture diagnosed on a chest radiograph.

Similar studies have been performed using multidetector CT (MD-CT) datasets that showed that without sagittal reformations or dedicated evaluation of the scout radiographs a