Diagnostic challenge: osteoporotic X pathologic (tumorous) fractures of vertebrae

Desafio diagnóstico: fraturas osteoporóticas X fraturas patológicas (tumorais) das vértebras

ABSTRACT

Osteoporosis is an extremely common metabolic disorder that can accompany a variety of disease processes. In the vertebral bodies, characteristic changes in radiolucency, trabecular pattern, and osseous contour are encountered. Additional manifestations of osteoporosis include acute and insufficiency stress fractures and bone bars (reinforcement lines). Owing to the inadequacies of routine radiography, and even scintigraphy, in allowing differentiation between nontumorous and tumorous compression fractures of vertebral bodies, the role of MR imaging in this differentiation has been studied. Routine spin echo sequences generally allow discrimination between compression fractures related to skeletal metastasis (or other tumors) and those that are chronic in nature and are related to benign causes such as osteoporosis. Difficulty arises, however, in differentiating with MR imaging between tumorous fractures and those that are benign but more acute. The typical appearance of chronic nontumorous or benign fractures of the vertebral body on spin echo sequences relates to the presence of signal intensity of the marrow in the affected vertebral body identical to that of the normal. Pathologic vertebral fractures caused by metastasis (and other tumors) reveal low signal intensity on T1-weighted images and high signal intensity on T2-weighted images, and similar but less pronounced changes in signal intensity accompany acute (less than 30 days old) benign compression fractures. Chemical shift and STIR sequences can serve as effective supplementary techniques in these situations, as can intravenous gadolinium administration.

KEY WORDS: spinal fractures, osteoporosis, neoplasm metastasis, magnetic resonance imaging

INTRODUCTION

Osteoporosis is the most frequent metabolic bone disease. In this disease, a generalized decrease in bone mass is seen. The remaining bone is normal structurally as determined by histologic and chemical analysis.

The diagnosis of osteoporosis of the spine is made on the basis of changes in radiolucency of the bone, in trabecular pattern, and in shape of the vertebral bodies1,2. Acute fractures are an important complication of osteoporosis3; the most common sites of such fractures are the vertebral bodies (Figure 1), the neck and intertrochanteric region of the femur, the distal portion of the radius, and the humeral neck.

Figure 1
Sagittal T1-weighted image showing acute osteoporotic fracture in the lumbar spine

The spine represents the most frequent site of skeletal metastasis. Involvement of the thoracic and lumbar levels predominates, although the sacrum often is affected. The cervical vertebral bodies are involved less typically4. Metastases more commonly occur in the vertebral bodies than in the posterior osseous elements. Of the malignant tumors that secondarily involve the spine, carcinomas of the lung, breast, and prostate (as well as lymphomas and plasma cell myeloma) are encountered most often.

The common occurrence of both osteoporosis and fractures of the vertebral body in postmenopausal women and in elderly men and women presents an immediate diagnostic challenge, particularly in those persons with a known extrasosseous malignant neoplasm. Is the vertebral collapse related to osteoporosis alone or does it indicate that the vertebral body contains metastatic foci? Although routine radiography may be helpful in addressing this question, the results of the routine radiographic examination may not be conclusive. The absence of osteolytic or osteosclerotic foci in the vertebral body, of pediculate destruction, of cortical disruption, or of an adjacent soft tissue mass is
reassuring evidence that tumor is absent, but unfortunately does not eliminate altogether the possibility of a pathologic (tumorous) fracture.\(^5,6\)

Destruction of one or both pedicles of a vertebra represents a well-known roentgenographic finding of skeletal metastasis that rarely is evident in plasma cell myeloma. It is best observed in the anteroposterior radiograph as an absence of one or both “eyes” of the vertebral body. Osteosclerosis of a pedicle is apparent in some patients with skeletal metastasis and is a reported (albeit rare) manifestation of Paget’s disease\(^7\) (Figure 2). The diagnostic importance of pediculate destruction as a sign of skeletal metastasis has led to a misconception that pediculate localization is more frequent than that in the vertebral body in cases of metastatic disease. Such is not the case. Indeed, studies using CT\(^8\) or MR imaging\(^9\) clearly have shown that involvement of the pedicle usually occurs as a result of further extension of a tumorous deposit within the posterior portion of the vertebral body (Figure 3).

MR imaging can be used effectively in this clinical setting if certain diagnostic pitfalls are taken into account. The potential value of this technique relies on alterations in the signal intensity of the bone marrow in the involved vertebral body that allow differentiation of a tumorous process from that accompanying osteoporosis alone.

In middle-aged and elderly persons, in whom the differentiation of “benign” versus “malignant” osteoporotic vertebral body fractures most commonly is required, the MR imaging signal intensity of the normal vertebral marrow generally is dominated by its fatty content. Therefore, with standard spin echo technique, high signal intensity on T1-weighted images and intermediate signal intensity on T2-weighted images in the normal marrow of the vertebral body is expected. In the presence of tumor or any other condition in which replacement of marrow fat has occurred, a decreased signal intensity is seen in the marrow on T1-weighted images (Figure 6), and T2-weighted images show either low or high signal, depending on the specific pathologic process that is present\(^10\). With most tumors, foci of increased signal intensity are noted on T2-weighted spin echo images.
The benefit that any or all of these MR imaging methods bring in allowing discrimination between “pathologic” and “benign” osteoporotic fractures of the vertebral body depends on the existence of different signal intensity characteristics in the two types of fractures. Herein lie some of the limitations of MR imaging in this clinical setting. The MR imaging findings of a so-called benign fracture, in common with the scintigraphic abnormalities, are dependent in part on the age of the fracture. Hemorrhage and edema initially occurring after a vertebral fracture would be expected to resolve over a period of time, although the precise length of time required for complete resolution is not clear and, in fact, may be variable. With bone scintigraphy, the abnormal accumulation of the radionuclide at the site of fracture (which usually is apparent within 48 hours of fracture) may diminish progressively and disappear altogether over a period of 1 or 2 years\textsuperscript{11}, but this time course is variable and, in some cases, abnormal scintigraphic activity persists for many years or even indefinitely\textsuperscript{12}.

“Fat” images in patients with acute benign fractures generally showed only partial replacement of the signal of normal fatty marrow by signal of low intensity (Figure 1), in contrast to the complete absence of normal marrow signal typical of pathologic fractures.

Yuh et al.\textsuperscript{13} postulated that in cases of tumor, vertebral compression occurs only when the entire bone marrow in the vertebral body is replaced and, in cases of osteoporosis alone, the bone marrow in the vertebral body remains relatively intact and is displaced in accordance with the vector of the compression force. Thus, the authors\textsuperscript{13} observed that even in instances in which incomplete replacement of marrow signal was evident (category 2), areas of such replacement were poorly defined and irregular in cases of tumor and smooth in cases of osteoporosis alone. As in the study of Baker et al.\textsuperscript{10}, some diagnostic problems occurred, however, in Yuh et al.\textsuperscript{13} analysis of MR imaging patterns in patients with acute non-neoplastic fractures of the vertebral body. Furthermore, common to both studies was the assumption that the abnormal MR imaging signal associated with such acute fractures would convert to normal over a period of time, allowing their differentiation from tumoral fractures, in which signal aberrations would be persistent and progressive.

The fluid sign was correlated with the cause, age and severity of vertebral fractures. In fractured vertebral bodies, the fluid sign is adjacent to the fractured end plates and exhibited signal intensity iso-intense to that of cerebrospinal fluid. The fluid sign can be linear, triangular or focal and occurs much more frequently on osteoporotic then neoplastic fractures. In osteoporotic fractures, the fluid sign is significantly associated with fracture severity. It can be an additional sign of osteoporosis and rarely occurs on metastatic fractures\textsuperscript{14}.

There has been considerable interest in the use of intravenous gadolinium administration to assess vertebral metastasis with or without extension into the epidural space\textsuperscript{15,16}. In general, the pattern and extent of tumor enhancement after such administration are variable; some metastatic lesions enhance markedly, others slightly, and still others not at all\textsuperscript{17}. Furthermore, enhancement may be homogeneous, initially peripheral with subsequent central spread, or random.

In patients with multiple lesions, the pattern of enhancement may vary from one lesion to another\textsuperscript{17}. Diagnostic difficulty may arise when T1-weighted gadolinium-enhanced MR images are used alone; metastatic lesions in the vertebral bone marrow may enhance so that their signal intensity may be similar to or identical with that of the marrow itself, decreasing significantly their conspicuity. Because of this possibility, it is important to obtain precontrast spin echo MR images\textsuperscript{15}. Short tau inversion recovery (STIR) sequences also can be used as an adjunct to the unenhanced and gadolinium-enhanced spin echo MR images\textsuperscript{16,18}.

The value of gadolinium-enhanced MR imaging may be increased with the supplementary use of fat-suppression techniques.

The initial experience exploring the diagnostic role of MR imaging in the assessment of vertebral compression fractures has been encouraging, but the preliminary nature of the data must be recognized, as must the need for other studies, prospective in nature, employing greater numbers of patients.
REFERENCES