2
Imaging of Spinal Tumors

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Key Points

- Primary spinal tumors are rare, metastasis to spine is common and comprise 90 percent of spinal column tumors.
- The advent of MRI revolutionized the characterization of spinal tumors by providing detailed direct visualization of the bone marrow and spinal cord in multiple planes, allowing earlier detection and treatment for both intradural and extradural tumors.
- Sagittal T1-weighted and STIR images are the most sensitive sequences for the bone marrow lesions, even in the early phase. Contrast-enhanced T1-weighted images are more sensitive when fat-saturation is applied.
- Whole body MRI with STIR sequence is currently possible in a short scan time revealing metastatic disease in both the spine and in solid organs.
- Differentiating osteoporotic acute compression fractures of the vertebra from malignant compression fractures is challenging even with MRI. MR techniques, such as DWI or chemical shift imaging, have been studied and quantitative techniques might be helpful.
- Early signs of cord or cauda equina compression is progressive sharp nerve root pain aggravated by bending or coughing; a limited sagittal T2-weighted MRI of the spine would be enough to evaluate compression.
- Most (90 percent to 95 percent) of the intramedullary tumors are malignant and predominantly composed of glial components. The most common types are ependymomas in adults and astrocytomas in children.
- Advanced imaging techniques such as MR spectroscopy, DWI, MT, and functional studies are currently limited by the strong magnetic field inhomogeneities

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present in the spinal cord region, respiratory and cardiac movements, and the small size of the spinal cord.
• We recommend the use of vertebroplasty for painful destructive vertebral lesions. The few complications reported have mostly been related to excessive cement injection, underlining the need of excellent imaging conditions to control the cement injection.

Spinal tumors can be grouped into 2 main categories: extradural (bone) and intradural. Intradural tumors are further grouped into intradural/intramedullary and intradural/extramedullary components.

Oncologists more commonly treat extradural malignant spinal tumors. Therefore, we will concentrate more on this group of tumors, complications such as compression fractures or cord compression and the percutaneous therapy with vertebroplasty. Relatively common benign and malignant primary bone tumors of the vertebrae are also briefly discussed, as well as the common intradural extramedullary and intradural intramedullary tumors.

1   Extradural Tumors

1.1   Malignant

1.1.1   Metastasis

The spine is a common site for metastatic disease of the breast, prostate, lung, kidney, thyroid, uterine carcinoma and melanoma. The lumbar spine is the most affected, followed by thoracic, cervical spine and sacrum [1]. Once established in an osseous location, metastatic tumor cells activate osteoclasts, which ultimately lead to bone resorption. [2, 3]. Direct tumor cell bone lyses also ensues.

Conventional radiographs show metastatic bone lesions only after the loss of more than 50 percent of the bone mineral content at the site of the disease. However, they are helpful for characterization of the lesion as lytic, blastic or mixed. Additionally the fracture risk is traditionally determined on plain radiographs [4].

Computed tomography (CT) is valuable as an adjunct in detailing osseous anatomy, character and extent of the specific lesion. Also CT is used for guiding biopsies for previously detected vertebral lesions.

MRI is a sensitive modality for the detection of metastatic disease and sometimes it provides improved specificity in characterization of the lesion. MRI can evaluate the lesion, its intramedullary and extramedullary extent, the degree of cortical involvement, the absence or presence of periosteal involvement and the extent of the soft tissue mass. Another advantage of MRI is to detect compressive myelopathy.

The vertebral metastasis may be focal or diffuse, and diffuse metastasis may show a homogenous or heterogenous signal pattern on MRI. Diffuse inhomogenous metastasis can be differentiated from normal inhomogenous fatty marrow in elderly
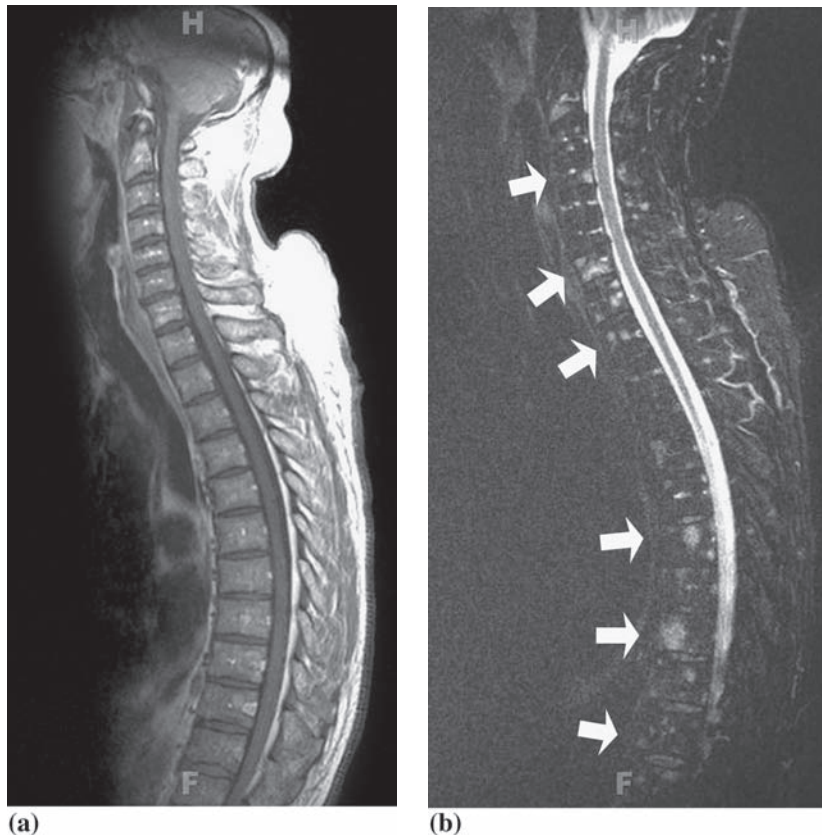
Fig. 2.1 Diffuse prostate cancer metastasis. (**a**) Contrast-enhanced sagittal T1-weighted MR image does not reveal a definite enhancing lesion. (**b**) Sagittal STIR sequence shows multi-level bright tumor deposits (arrows) on the background of suppressed fatty marrow signal

individuals by using a short tau inversion recovery (STIR) sequence which shows multiple bright metastatic deposits within the background of dark patchy fatty marrow (Fig. 2.1).

Lytic lesions may be seen in almost all tumor types. Bone metastases of bladder, kidney and thyroid cancer are invariably lytic. The lytic lesions usually show avid contrast enhancement on fat-saturated T1-weighted images (Fig. 2.2). Blastic lesions are frequently seen in prostate and breast cancer, occasionally in lung, stomach, pancreas and cervix carcinomas, and infrequently in colorectal cancer [5]. MRI shows focal areas of low signal intensity on both T1- and T2 sequences, and high signal intensity on STIR, though less conspicuous than the lytic pattern.

With the recent development of turbo STIR sequences, it is possible to image the whole body in 30 to 40 minutes by using MRI, which also reveals solid organ
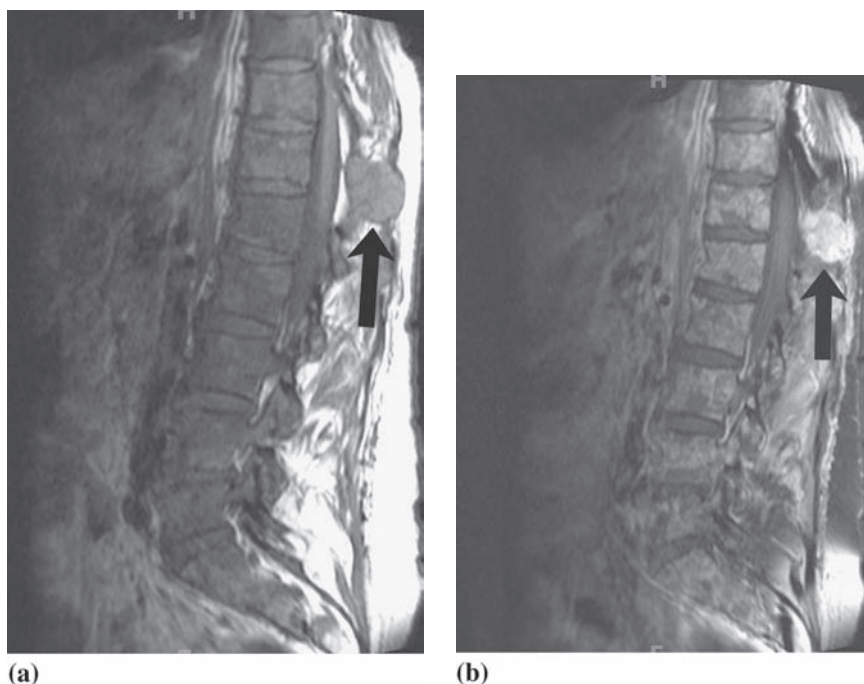
Fig. 2.2 Diffuse breast cancer metastasis with soft tissue component. (**a**) Sagittal T1-weighted MR image shows diffuse decreased signal of the vertebrae that is almost isointense with the intervertebral discs. There is posterior soft tissue mass at T12 level (arrow). (**b**) Contrast-enhanced fat-saturated sagittal T1-weighted image demonstrates heterogenous enhancement of the vertebrae and the metastatic soft tissue mass (arrow)

metastasis such as liver, lung or brain, in addition to axial and peripheral skeleton metastasis [6, 7, 8]. Eustace, et al. [6] compared scintigraphy to whole body turbo STIR MRI in 25 patients with known or suspected skeletal metastasis and found that MRI is 96.5 percent sensitive and 100 percent specific with a positive predictive value (PPV) of 100 percent, whereas scintigraphy is 72 percent sensitive and 98 percent specific with a PPV of 95 percent.

1.1.2 Lymphoma

Primary bone involvement occurs in 3 percent to 5 percent of the patients with Non-Hodgkin's Lymphoma, and 25 percent of them have secondary bone involvement. Primary bone involvement is rare in Hodgkin's disease. Secondary bone involvement occurs in 5 percent to 20 percent of patients with Hodgkin's disease during the course of the disease, but in only 1 percent to 4 percent at presentation. The radiographic and CT findings are nonspecific and represent late manifestations, more commonly osteolytic; ranging from a permeative moth-eaten pattern to a more geographic area of osteolytic destruction [9]. Patchy sclerosis, mixed osteolytic-sclerotic pattern and, rarely, "ivory vertebrae" are seen.
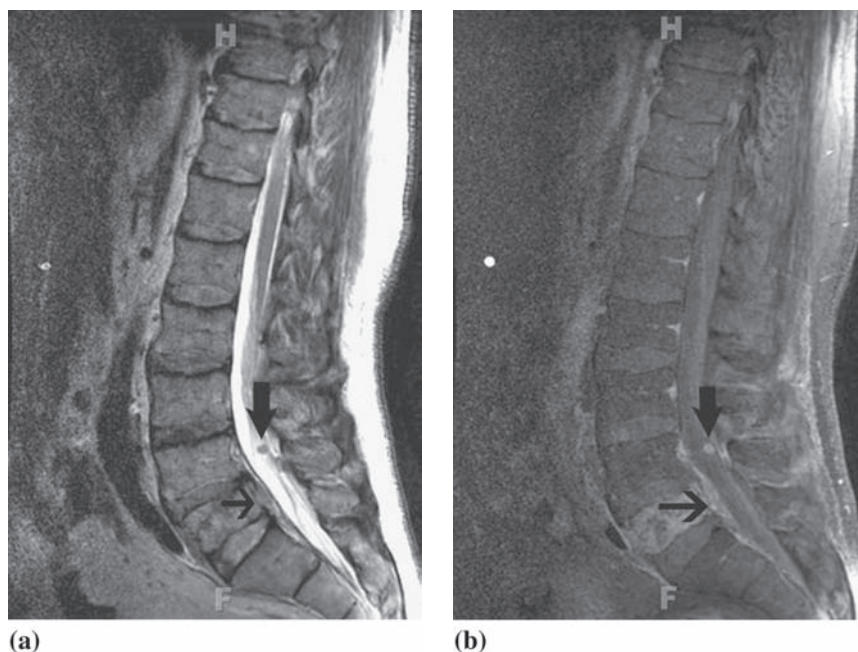
Fig. 2.3 Metastatic B-cell lymphoma. (**a**) Sagittal T2-weighted MR image shows slight heterogenous signal in L5 vertebra, soft tissue mass in the anterior epidural space (thin arrow) and a small hypointense nodule within the thecal sac adjacent to cauda equina roots at L4 level (arrow). (**b**) Contrast-enhanced fat-saturated T1-weighted sagittal image reveals bone marrow metastasis in L5 showing diffuse heterogenous enhancement with an enhancing soft tissue component in the anterior epidural space (thin arrow) and intradural extramedullary metastatic nodule also showing enhancement (arrow)

Lymphoma may produce diffuse infiltration of the bone marrow, usually in the low-grade Non-Hodgkin's type, and it can only be detected on MRI. T1-weighted images demonstrate diffuse hypointensity of the vertebrae and bright signal of the intervertebral discs. The finding of high signal intensity marrow on T2-weighted fat-suppressed images or an obvious contrast enhancement, particularly on fat-saturated contrast-enhanced T1-weighted images, help to differentiate it from normal hypercellular marrow. In Hodgkin's lymphoma, intermediate and high-grade non-Hodgkin's lymphoma, the bone involvement is usually focal. In Non-Hodgkin's lymphoma epidural soft tissue mass can occur alone or as a component of vertebral or paraspinal tumors, and this might be present either at diagnosis or during the disease course (Fig. 2.3).

1.1.3 Leukemia

Leukemia usually shows diffuse bone marrow infiltration, rather than focal disease, and results in a decreased signal on T1-weighted images, presenting diagnostic challenges similar to diffuse lymphoma. In both diseases the decrease in bone marrow signal intensity

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