Introduction

There are a large number of tumour types that affect the musculoskeletal system reflecting the different cellular constituents of bone, bone marrow and of the associated tendons, ligaments and muscles. The incidence of tumour types varies in the spine compared to the appendicular skeleton, reflecting the persistence of haemopoietic marrow in the axial skeleton into adulthood and the epiphyseal growth activity in the appendicular skeleton of children. The embryological development of the spine from the notochord results in tumours specific to the spine and skull. The spine may also be indirectly affected by tumours developing in the spinal cord, meninges and nerve roots that pass through the spinal canal and foramina.

As with the appendicular skeleton, the incidence of differing tumours varies depending on patient age, with some lesions being primarily limited to the growing spine while others only present in the mature skeleton. The structural similarity of each level of the spine means that most tumours may occur at any level, although there are variations in the incidence in different sections. The vascularity of the spine and its increased haemopoietic activity also makes it a natural repository for malignant cells from other tumours so that the incidence of clinically manifest metastases is higher in the spine than in the appendicular skeleton. The high ratio of trabecula to cortical bone in comparison to the long bones also renders the vertebra biomechanically vulnerable to bone replacement by primary or metastatic tumour, resulting in collapse of the vertebral body. The thin cortical bone of the vertebral body is less able to restrain the tumour growth, with resultant expansion beyond the confines of the vertebra, which may result in compression of the adjacent spinal cord or nerve roots. Vertebral collapse may also limit the space within the spinal canal and foramina, resulting in clinically manifest neurological deficit. Vertebral collapse from trabecula fractures or tumour replacement of trabecula bone may also irritate pain nerve endings in the bone; backache is the most common presenting feature. In many cases, this is not specific but pain of severe and sudden onset or pain that is continuous and unrelieved by lying down or exercise is a clinical pointer to the presence of a spinal tumour. Occasionally the pain pattern has specific features, as with osteoid osteoma, but this is unusual.

Some spinal tumours are more common in specific parts of the vertebra, again reflecting the structural differences of the vertebral body and the posterior elements, which have a low marrow content and thicker cortical bone. However, tumour originating from one part of the vertebra will easily extend or invade another part, as there are no natural boundaries. Tumour extending into the lamina from the vertebral body must disrupt the pedicles, providing a very specific feature on the radiographs. This is important, as considerable trabecula destruction may occur within the vertebral body before it becomes visible on a radiograph.

Tumour extension from the vertebral body or posterior elements results in a para-vertebral or pre-vertebral mass of tumour which may invade or displace the adja-
cent tissue, becoming visible on the radiographs in the thoracic spine and to a lesser extent in the cervical spine due to the close proximity of the air-filled structures, which provide the necessary radiographic contrast with the tumour tissue.

Radiographs remain the initial investigation in most cases of suspected spinal tumour but magnetic resonance (MR) may be the appropriate first investigation in some instances, in particular in the demonstration of metastases in cases where a primary neoplasm is known or where neurological symptoms and signs are the presenting clinical features. MR is the most sensitive method to identify marrow replacement by tumour in the vertebral body but is less effective in identifying focal lesions in the cortical bone of the posterior elements. MR may also fail to identify the presence of calcification or ossification within a tumour and define the bone reaction at the margin of the tumour. While these may be evident on the radiographs, they are best identified on computed tomography (CT). Finally, isotope studies using bone seeking technetium-labelled methylene diphosphonate (\(^{99m}\)Tc-MDP) may identify occult bone lesions, although they are more accurate in lesions which are bone-producing and may not identify lesions which are purely destructive. They have the additional advantage of being able to examine the whole skeleton at one time, providing an opportunity to identify extensive metastatic involvement. Whole-body MR is available in some systems and although not widely used at the present time, its value is being actively investigated [1].

### Tumours of the Haematopoietic System

#### Multiple Myeloma

Multiple myeloma is the most common primary malignant tumour involving the spine. It is rare before the age of 40 years and involves mainly the axial skeleton.

Pathologically the gross specimen shows either diffuse gelatinous red infiltration or tumour in a nodular pattern. Histologically, marrow becomes infiltrated with sheets of proliferating plasma cells and B cells. There is considerable pleomorphism of the nuclei and an increase in mitoses (Fig. 1). The B cells produce abnormal protein gammaglobulins with an increase in IgA and a decrease in IgG and IgM bands on serum protein electrophoresis. Light chain subunits of immunoglobulins, Bence-Jones protein, is excreted in the urine.

The proliferation of cells leads to a replacement of the trabeculae resulting in areas with no bone present (Fig. 1). These may extend into the pedicles but usually commence in the bodies. The resorption of bone may result in vertebral collapse and a soft tissue mass may extend beyond the margins of the vertebra and lead to narrowing of the spinal canal.

Radiographs may show generalised osteopaenia with a loss of sharpness of the trabeculae (Fig. 1), but well-defined lytic lesions without any surrounding sclerosis may be seen and these may be multiple (Fig. 1). The vertebral bodies are involved initially with pedicular involvement late in the disease process. Paravertebral masses may be seen and vertebral collapse may be present. CT will demonstrate the extensive bone loss without evidence of calcification or of residual fragments of bone (Fig. 2). Extensive destruction of cancellous bone contrasting with the relative preservation of cortical bone on CT is suggestive of myeloma in comparison with both cancellous and cortical destruction with metastases [2]. The extent of the soft tissue mass is also demonstrated on CT but is better visualised on MR, which demonstrates decreased signal on the T1-weighted sequences and increased signal on T2 and STIR. These features are not specific for myeloma and metastases will also produce a similar pattern. Soft tissue extension into the spinal canal may cause spinal cord or cauda equina compression. Radioisotope studies are of little value in myeloma, as there is no new bone formation, and although reduced uptake may be present, it is generalised and difficult to perceive.

#### Plasmacytoma

Plasmacytoma is a solitary lesion, which presents with localised pain but also may initially present with paraparesis or paraplegia. Pathologically it consists of plasma cells and may precede the onset of myeloma by up to 10 years. The histological appearance is similar to myeloma with large numbers of plasma cells, but the mitotic activity is less (Fig. 3).

Radiographically it may present as a solitary expanding lucent lesion in the vertebral body or posterior elements. MR is the investigation of choice. On T1 there is an expanding tumour of uniform intermediate intensity slightly higher than muscle, which has a well defined margin and may have a lobulated outline (Fig. 3). On T2 there is a uniform high signal intensity which is also present on the STIR sequence (Fig. 3). The spinal cord or cauda equina may be compressed by the mass. CT provides little additional information but confirms the absence of any surrounding bone production or sclerosis and any calcification in the tumour. Radioisotope studies may demonstrate a local loss of activity.

#### Lymphoma

Lymphoma can arise in lymphoreticular tissue anywhere in the body but the majority of cases of musculoskeletal lymphoma develop via secondary spread through haematogenous dissemination from nodal dis-