Radiographic Imaging of Musculoskeletal Neoplasia

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Background: Imaging is an integral part of the diagnosis, staging and evaluation of outcomes for bone and soft-tissue neoplasms. Each of the available imaging tools has a different role.

Methods: The authors reviewed the efficacy of the current imaging modalities in the diagnosis, staging, and follow-up of patients with musculoskeletal neoplasia.

Results: Plain-film radiography remains the gold standard in the differential diagnosis of bone lesions. Bone scintigraphy is an excellent screening modality, and computed tomography is especially useful in evaluating lesions of the axial skeleton. The superior soft-tissue resolution and multiplanar capabilities achieved with magnetic resonance imaging, however, has replaced the need for CT scans in many cases.

Conclusions: The technological advances seen in recent years in all areas of imaging have improved the capabilities of these modalities to assist in the diagnosis, definition of tumor extent, and accurate staging of musculoskeletal tumors.

Introduction

The last two decades have witnessed a dramatic change in the approach to the treatment of musculoskeletal neoplasia. The development of more effective chemotherapeutic agents, combined with improvements in limb salvage surgery and advances in imaging technology, has resulted in improved staging and ultimate outcome in patients with these bone and soft-tissue lesions.

The role of medical imaging in diagnosis, staging, and eventual follow-up of patients with musculo-
skeletal neoplasia has expanded, particularly as high-quality magnetic resonance imaging (MRI) has become a common tool in the armamentarium of most practitioners. This article presents an overview of the imaging modalities currently used in evaluating musculoskeletal lesions, discusses the role that each diagnostic entity plays in tumor staging, and provides a glimpse of what the future holds for further technological advancement.

Standard Radiography

Despite advances in imaging technology, plain-film radiography remains the gold standard for establishing an accurate differential diagnosis for bone lesions. When evaluating the solitary bone lesion, one of two approaches can be taken: the “Aunt Minnie” approach (“I’ve seen this lesion before and recognize it”) or the analytic approach, which depends on various radiographic signs. The obvious limitation to the former approach is the need for vast experience and a superb memory. The latter allows the formation of a reasonable differential by understanding the pathophysiology and significance of the observed radiographic changes.

Lodwick et al classified the plain-film appearance of lucent bone lesions as geographic, moth-eaten, and

1A

Fig 1A. — Geographic lesion with a sclerotic margin, type IA. A healing nonossifying fibroma is present in the posterior aspect of the distal femur. The margin (arrows) of the lesion is well defined with a thin sclerotic margin.

1B

Fig 1B. — Geographic lesion with well-defined rim, type IB. Giant cell tumor is seen involving the distal tibia. The lesion is eccentric and expansile extending to the articular surface. The margin (arrows) of the lesion is nonsclerotic but well defined.

1C

Fig 1C. — Moth-eaten lesion, type II. A metastatic adenocarcinoma lesion is present involving the intertrochanteric and subtrochanteric region of the right femur. The margins (straight arrows) are less well defined with a slightly wider zone of transition than the margins of a type I lesion. There is mild endosteal scalloping (curved arrow) of the cortex along the medial aspect of the femur.

1D

Fig 1D. — Permeative lesion, type III. A large lytic lesion is present involving the right ischium and pubic bone. The lesion represents primary bone lymphoma. The margins (arrows) demonstrate a wide zone of transition between the normal and pathologic bone. There is extensive destruction of the normal bony architecture.
permeative. Geographic lesions (type I) are generally well-circumscribed “holes” in bone that can be further subclassified by the appearance of the border as IA (sclerotic), IB (well defined), or IC (poorly defined). Moth-eaten lesions (type II) generally represent a confluence of small lytic areas in the bone such as those seen in metastatic disease. Permeative lesions (type III) preserve the outline of the bone but reveal numerous small, diffuse lytic lesions such as those commonly seen in round cell tumors (eg, Ewing’s sarcoma, myeloma) (Figs 1A-D). Increasing the radiographic grade generally corresponds well with the aggressiveness of the lesion. Indeed, the radiographic appearance of the margin tends to correspond well with the aggressiveness of the tumor.4 Enneking5 classified lesions of bone as latent, active, or aggressive, based on the radiographic appearance. In latent lesions, a thick reactive rim of bone forms around the tumor. In active lesions, a thin cortical shell may form around the lesion. This shell often appears expansile, even through the cortex, where new periosteal bone will form around the tumor mass. Aggressive lesions lack a rim of reactive bone as rapid growth of the tumor prevents bone formation in the reactive zone surrounding the lesion.

Additional clues about the lesion can be obtained from endosteal and periosteal reactions. Endosteal scalloping is indicative of a more active lesion, although it may slowly form over a prolonged period of time. Periosteal reaction varies widely and represents involvement of the outer cortical rim by the tumor or its reactive rim. These reactions have been classified as solid, spiculated (eg, hair on end, sunburst), Codman’s triangle, unorganized, or sloping (velvet) based on the appearance and aggressiveness of the lesion (Figs 2A-B).1 While most lesions do not produce matrix and appear radiolucent, matrix production, when present, may provide additional diagnostic information. For example, osteosarcomas often produce cloudy, amorphous new bone. Fibrous dysplasia appears as the classic “ground glass” in bone. Chondroid lesions frequently present as calcified “rings and arcs,” and intramedullary infarcts give a “smoke up the chimney” appearance (Figs 3A-C). When attempting to diagnose a bone lesion on radiographic criteria alone, several parameters may aid in the formulation of an appropriate differential diagnosis.6 These parameters include the following: (1) age of the patient (eg, round cell lesions may present as eosinophilic granuloma in the first decade, Ewing’s sarcoma in the second decade, lymphoma in the fourth or fifth decade, and myeloma thereafter), (2) location of the lesion (eg, chondroblastoma or giant cell tumor is found in the epiphysial or subchondral location or fibrous dysplasia in the diaphysis), (3) singularity or multiplicity of the lesion (multiplicity suggests such lesions as metastasis, histiocytosis X, or enchondromata), (4) size of the lesion (larger lesions tend to be more aggressive), (5) presence of tumor matrix (discussed above), and (6) local behavior of the lesion (also discussed above). Careful attention to these parameters will assist the clinician in the formation of a reasonable differential diagnosis.

Four lesions - fibrous dysplasia, metastatic carcinoma, infection, and chondroid tumors — present in such a variable fashion

Fig 2A. — Solid periosteal reaction. An osteoid osteoma is present within the medial cortex of the femur. A faint radiolucency is present representing the fibrovascular nidus (curved arrow). There is thick solid periosteal reaction (straight arrows) resulting in adjacent cortical thickening.

Fig 2B. — Spiculated periosteal reaction and Codman’s triangle. A patient with Ewing’s sarcoma involving the mid femoral shaft demonstrates both spiculated periosteal reaction (open arrow) and Codman’s triangles (solid arrows).
that they can virtually “look like anything” (H. J. Mankin, personal communication, 1991). Over the years, a fifth lesion with a widely varying presentation — eosinophilic granuloma — has been added. These five lesions may well considered in the differential diagnosis of most unknown bone lesions.

In soft-tissue lesions, plain radiographs provide limited information, with a few noteworthy exceptions. Soft-tissue tumors juxtaposed to bone may cause focal cortical erosion (eg, fibrosarcoma) or reactive periosteal changes (eg, hemangioma). Normal distinct fatty planes are typically obscured as neoplastic or inflammatory lesions displace them, while lipomas may be identified by their radiolucent appearance compared to the surrounding soft tissue. Calcification in the soft tissue may suggest liposarcoma or synovial cell sarcoma, while phleboliths may be seen in vascular lesions. Ossification in the soft tissues is suggestive of myositis ossificans. Myositis ossificans frequently demonstrate a cleavage plane between the lesion and the bone, while parosteal osteosarcomas have a “stuck-on” appearance to bone, and osteochondromas share the cortex and medullary space with the bone. The zonation phenomenon noted by Ackerman should be considered when evaluating soft-tissue lesions that mineralize. This implies more uniform mineralization from the periphery of the lesion in myositis compared with more central, “fluffy” mineralization in soft-tissue neoplasia. Mineralization patterns notwithstanding, plain films are generally nonspecific for the evaluation of soft-tissue tumors, particularly if the lesion is similar in density to the surrounding musculature.

Bone Scintigraphy

Bone scintigraphy (bone scan) is a commonly used modality in the evaluation of musculoskeletal lesions. While the technology has been available for decades, the use of technetium-labeled radionuclides and more modern gamma cameras has led to a significant decrease in the patient radiation dose and an increase in diagnostic information, thus resulting in its widespread use as a screening tool today.

Bone scintigraphy is a nonspecific but sensitive modality for assessing abnormalities in bone formation and bone perfusion. While plain films require approximately 50% loss of mineralization to allow detection of destructive lesions of bone, scintigraphy is an excel-

Fig 3A. — Osteoid matrix. A large bone island is present in the iliac crest. The matrix (arrow) of the lesion is cloudy in appearance.

Fig 3B. — Chondroid matrix. A low-grade chondrosarcoma of the proximal humeral metaphysis demonstrates punctate appearing calcifications (arrow) in the center of the lesion. The calcifications have the typical “rings and arcs” appearance of chondroid matrix.

Fig 3C. — Fibrous matrix. An example of fibrous dysplasia involving the proximal shaft of the tibia demonstrates the hazy “ground glass” appearing matrix (arrow) typical of a fibrous lesion.
lent screening modality to detect lesions not otherwise seen on routine radiographs. This is particularly helpful in evaluating metastatic disease in the patient with a known primary tumor (with the exception of renal cell or thyroid metastasis, which may appear cold on routine screening).

The presence or absence of radiopharmaceutical activity, while not specific for benign or malignant lesions, is nonetheless helpful in identifying active vs indolent lesions of bone. Slow-growing indolent lesions (eg, nonossifying fibroma, osteochondroma, enchondroma) generally demonstrate minimal uptake. Such appearance of relative inactivity can help to formulate an appropriate diagnosis of an otherwise uncertain lesion. Bone-forming lesions such as osteoid osteoma and osteosarcoma demonstrate intense uptake of the tracer, reflecting their active nature. Conversion of a bone lesion from relatively inactive to active on scintigraphy is generally suggestive of malignant transformation, although it may also be seen in lesions that are “burning out” (eg, nonossifying fibroma) or in cases of pathologic fracture.

Bone scintigraphy is an excellent tool to screen for multiple skeletal lesions, which may present in a variety of diagnoses such as multifocal osteomyelitis, multiple

![Fig 4A. — Bone scan; unifocal lesion with minimal uptake. The bone scan demonstrates minimal increased uptake (arrow) in a fibrous dysplasia lesion involving the proximal left femur. Minimal uptake typically indicates that the lesion is slow growing or inactive.](image)

![Fig 4B. — Bone scan; unifocal lesion with marked uptake. This case of a giant cell tumor involving the distal ulna demonstrates marked uptake (arrow) indicating an active lesion. Although the lesion is active, the degree of uptake does not indicate whether the lesion is benign or malignant.](image)

![Fig 4C. — Bone scan; multifocal lesions. A patient with metastatic prostate carcinoma demonstrates multiple lesions within the axial skeleton. Bone scan is a sensitive screening tool to survey the entire skeleton for the presence of lesions.](image)
osteochondromas or enchondromas, multifocal osteosarcoma, or metastatic disease from any primary source. Knowledge of multifocality is important, since it generally has a profound impact on the treatment modalities required (Fig 4A-C).

Additional radiopharmaceuticals are available as adjuncts to standard bone scintigraphy to provide added diagnostic information. Gallium can be used to help to distinguish benign from malignant lesions, and it displays special affinity to such lesions as myeloma and neurofibrosarcoma.\(^8\) Indium is useful in the detection of acute infection. Sulfur colloid is effective for imaging bone marrow and can identify areas of red marrow replacement. Thallium has some value in detecting the viability of bone sarcomas or the presence of recurrence.\(^9\)

In soft-tissue lesions, scintigraphy is relatively non-specific for diagnostic purposes. Soft-tissue lesions show variable radiopharmaceutical uptake, but in general, most malignant lesions exhibit increased uptake, while benign lesions tend to exhibit little or no intrinsic uptake.\(^10\)

**Computed Tomography**

Since its clinical inception in the 1970s, computed tomography (CT) has provided an additional diagnostic tool that has the advantage of high-contrast resolution and cross-sectional imaging (with potential 3-dimensional reconstruction) over plain radiographs. Simply put, a narrowly collimated x-ray beam is passed through the body at many different angles, and a series of attenuation profiles are measured. A computer then processes the data to create an image using various shades of gray. A unit of attenuation (density) is referred to as a Hounsfield unit (HU). Different body tissues attenuate the x-ray beam at different rates depending on the density of the specific tissue. The attenuation of fat is generally in the range of \(-130\) to \(-70\) HU. Fluids range from 0 to +30 HU, depending on their contents. Muscle and soft-tissue tumors range from +40 to +60 HU, and bone results in attenuation values of greater than +1,000 HU.\(^11\) The determination of these various attenuation values or densities can help to distinguish between fatty, solid, cystic, and mineralized lesions.

The ability of CT to improve lesion characterization in both soft-tissue and bony lesions makes it a potentially important diagnostic tool. CT is especially useful in evaluating lesions of the axial skeleton such as the spine or pelvis, where the anatomy is complex, and cross-sectional imaging can eliminate overlap of different anatomic structures. Because of the high attenuation value of calcified or ossified tissue, lesions that contain calcification (myositis ossificans, synovial cell sarcomas, chondroid lesions, etc) are easily detected, and the architecture of bony lesions (either formation or destruction) is easily interpreted (Fig 5A-B). The low density of fat makes lipomas readily identifiable, and discreet areas of soft-tissue density within fatty lesions are suggestive of liposarcoma. Cystic lesions generally present as well-defined, homogeneous masses with atten-
ation values lower than muscle and higher than water, depending on fluid content.

The capability of displaying subtle differences in tissue density allows for improved recognition of both tissue type and tumor involvement. Unfortunately, in the absence of specific identifiable clues as mentioned above, CT imaging reveals masses that may enlarge or distort normal anatomy but fail to confirm a specific histologic diagnosis.

While CT remains an important imaging modality, the superior contrast resolution of MRI has replaced the need for CT scans in many cases of musculoskeletal neoplasia. However, CT remains far less sensitive to motion-related artifacts than MRI. Consequently, abdominal CT and chest CT remain particularly important tools in the staging process. The importance of CT in evaluation of pulmonary lesions cannot be overstated. Chest CT should be obtained in all cases of known or suspected malignant neoplasia to evaluate for the presence or absence of pulmonary metastases. Furthermore, CT remains the imaging modality of choice to evaluate the abdomen or pelvis for adenopathy or other signs of metastatic disease.

Magnetic Resonance Imaging

The development and clinical use of MRI over the last decade and a half have had a profound effect on the ability to image and consequently stage musculoskeletal neoplasia. The ability to image in multiple planes without loss of image resolution is a distinct advantage over CT imaging. While plain radiographs have a contrast resolution of approximately 1% and CT approximately 7%, MRI has a soft-tissue contrast resolution that exceeds 50%. Additionally, this high-resolution modality can be manipulated considerably by varying the signal parameters to obtain a wide variety of images that serve to better characterize tissue types based on their signal characteristics. This precise, high-resolution anatomic evaluation modality of musculoskeletal neoplasia has had a significant impact on the ability to appropriately stage lesions and adequately plan for limb salvage surgery.

MRI differs from x-ray–generated imaging in that MR images are based on the number of free water protons present within a tissue sample rather than on the density of the tissue sample. MRI consists of placing a patient in a strong external magnetic field followed by the application of specific radiofrequency (RF) pulses to excite the protons. As the protons return to their relaxed state, they emit energy, which is measured by a receiver coil and processed by a computer to generate an image.

Familiarity with the basic MRI terminology is necessary to gain maximum benefit from this advanced imaging modality. The field of view (FOV) is the size of the area being imaged. A small FOV allows for high spatial resolution, whereas a larger FOV diminishes the overall spatial resolution. Therefore, the FOV should be the smallest possible area that contains all the pertinent anatomy. A surface coil is a small RF coil that is placed directly on the area of interest. The close proximity of the coil to the area of interest allows for high signal-to-noise images. Spatial resolution is generally defined as the smallest lesion that could be diagnosed on a given image.

Several different pulse sequences are used in musculoskeletal imaging. The most commonly used are the spin-echo sequences. Spin-echo images are obtained by applying a series of RF excitation pulses followed by...
by a receiving coil to listen at a certain time for the energy released from the realigning protons. T1- and T2-weighted images are obtained in this manner. Time to recovery (TR) is the time needed to complete an entire cycle of RF pulses, and time to echo (TE) is the time interval between the initial RF excitation pulse and the time that the receiver coil listens for the returning signal from the realigning protons. A T1-weighted image has a short TR (400-600 msec) and a short TE (<30 msec), while a T2-weighted image has a long TR (>2000 msec) and a long TE (>70 msec). A proton density image has a long TR and a short TE. A gradient echo image is obtained by applying a series of external gradients (smaller superimposed magnetic fields) rather than by applying numerous RF pulses, as occurs in the spin-echo imaging. An inversion recovery image is obtained by applying RF pulses in a particular order to eliminate all signal, which normally would be produced by the presence of fat. This is a highly effective method of providing fat saturation, which increases the sensitivity of MRI in the detection most pathologic processes. By applying the various imaging techniques listed above, MRI can provide much better soft-tissue contrast than any other currently available imaging technique.

For all its high-resolution characteristics, MRI has limitations. It is inferior to CT for visualization of fine bony detail or small calcifications. Subsequently, thin rims of bone around expansile lesions or masses containing calcific densities may be best detected by CT. Furthermore, structures that tend to remain dark on all MRI sequences (cortical bone, tendons, air, fast flowing blood, etc) may be difficult to distinguish. Motion from uncomfortable or anxious patients or even from simple respiratory cycles can significantly alter image quality.

While the initial expectation that MRI would provide definitive tissue diagnosis has not been fully realized, certain clues from the signal characteristics of various pulse sequences can provide considerable diagnostic information. For instance, fat, gadolinium, methemoglobin (a breakdown product of blood), proteinaceous fluid, and melanoma appear bright on T1-weighted sequences.

Subcutaneous fat, fatty replacement in adult marrow, and lipomas demonstrate bright signal intensity on T1-weighted images. The presence of any tissue other than fat is seen as areas of low signal intensity on T1-weighted images. Within the marrow, adjacent muscle serves as an excellent internal standard. Hematopoietic marrow is typically brighter than adjacent muscle on T1-weighted images, while pathologic replacement of fatty marrow by metastatic tumors or skip lesions appear darker than adjacent muscle on T1-weighted images. When evaluating fatty lesions, the more complex the lesion (internal stranding, heterogeneous signal, nodules, or areas of enhancement), the higher the likelihood that the lesion represents a liposarcoma rather than a simple lipoma.

Intravenous gadolinium is distributed in areas of increased blood flow and vascular permeability. Hence...
it provides additional information that more clearly distinguishes between edema and areas of hyperemia. Increased signal intensity on T1-weighted gadolinium images may help to distinguish between viable tumor and the reactive edema surrounding the lesions seen on T2-weighted images. At our institution, we prefer to use fat-saturated T1-weighted gadolinium images to improve the contrast between hyperemic tissue and normal fatty tissue. Additionally, the “rim enhancement” seen in gadolinium images has proven useful in determining the presence of necrosis in otherwise “wet” tumors, and it assists in determining the cystic nature of many benign lesions.

The appearance of hemorrhage is variable and complex. Acute bleeds generally have a fluid-like appearance, but early degradation leads to the formation of extracellular methemoglobin. This deposition of methemoglobin in tissue is paramagnetic and appears bright on T1-weighted images.

T2-weighted images demonstrate increased signal with free water and therefore can help to identify cystic lesions, edema, and neoplasia. Tumors generally appear isointense on T1-weighted images but typically are bright on T2-weighted images. Exceptions to this rule are tumors with a high collagen content (densely fibrous lesions) that may demonstrate both low T1 and low T2 signal characteristics.

Cystic or fluid-containing lesions are bright on T2-weighted images but demonstrate low to intermediate signal on T1-weighted images. Cystic lesions that contain cellular debris or cystic lesions that contain two types of tissue, such as fluid and blood or fluid and fat, may create layering. This results in the so-called “fluid-fluid” layer seen in such lesions as aneurysmal bone cyst, giant cell tumor, chondroblastoma, and telangiectatic osteosarcoma.

Understanding the signal characteristics of the normal anatomic tissue assists in identifying abnormalities that may be present. In general, cortical bone, air, and ligaments are dark on all sequences, while muscle and cartilage tend to be intermediate in intensity on both T1- and T2-weighted sequences. As already noted, fat is bright on T1-weighted images and tends to gray slightly on T2-weighted images. The sharp contrast on T2-weighted images of most neoplasia when compared with normal tissue makes it an ideal sequence for visualizing pathologic tissue.

Other special sequences may be helpful in determining the presence of pathologic tissue. Such sequences include gradient echo images that demonstrate the “blooming artifact” seen in calcification or ferrous-laden tissue, which is present in synovial chondromatosis or pigmented villonodular synovitis, respectively. Inversion recovery sequences profoundly suppress fat and are exquisitely sensitive to free water, although at the expense of resolution and anatomic detail.

In summary, the superior soft-tissue resolution and multiplanar capabilities of MRI make it an ideal imaging tool for the evaluation of soft-tissue lesions.
modality for musculoskeletal neoplasia. Despite its modest limitations (ie, sensitivity to motion, inferior to CT for imaging fine bony detail), the excellent soft tissue contrast, superb anatomic detail, and exquisite sensitivity in marrow imaging make it indispensable in the staging of these lesions.

Future Trends in Imaging of Musculoskeletal Neoplasia

Important strides have been made over the past two decades in the imaging of musculoskeletal neoplasms. Advances in computer software have been primarily responsible for improvements in image spatial resolution and faster acquisition times. These advances have improved capabilities to precisely define the anatomic extent of a tumor and to more accurately stage musculoskeletal tumors preoperatively. Software advances continue at a rapid pace and will undoubtedly lead to additional improvements in all areas of imaging.

The most recent advance in the area of CT scanning is the development of the multislice CT scanner, which is now available for clinical use. Multislice CT scanners allow rapid acquisition of data combined with high spatial resolution. Large areas of the body can now be routinely imaged at 1-mm thickness. The data can then be viewed at any incremental thickness (eg, 5-, 8-, or 10-mm thickness). If there is a particular area of interest, the images can be viewed through that specific area at 1-mm thickness without rescanning the patient. In addition, sagittal and coronal images can be reconstructed with higher image resolution than was previously available on standard helical CT imaging. The rapid acquisition of images also allows for truly dynamic imaging during the administration of intravenous contrast. Finally, multislice CT scanning allows for high-resolution imaging adjacent to metallic hardware with minimal streak artifact. This represents an improvement over conventional CT scanning and may be useful when imaging the postoperative tumor bed adjacent to hardware (eg, a total joint prosthesis or an intramedullary rod).

Advances in MRI continue to result from faster computing times. High-resolution images can now be acquired in a matter of seconds rather than minutes, as was standard only a few years ago. Although these recent advances allow for faster imaging times, they have ultimately done little to improve our ability to provide an exact tissue diagnosis. Three important applications, however, have resulted from faster MRI computing times. Recent studies suggest that dynamic contrast-enhanced MRI may help in (1) defining areas of tumor viability prior to biopsy, (2) determining response to chemotherapy, and (3) evaluating tumor recurrence following surgery.20 Fast and ultrafast MRI allows for differentiation between earlier contrast enhancement of viable tumor and the more delayed enhancement of surrounding reactive tissue. Standard MRI acquires images over several minutes, so the areas of enhancement represent an equilibrium phase, demonstrating enhancement of both tumor and adjacent reactive tissue. Dynamic contrast-enhanced imag-
ing differs from standard images in that it provides sequentially obtained images every few seconds following administration of intravenous contrast and is capable of differentiating enhancement of tumor from the adjacent reactive tissues. While more work is needed in this area, early studies show promise regarding the capability of dynamic contrast-enhanced MRI to more accurately define the precise extent of tumor and to monitor for recurrence.

Recent developments in MRI and CT imaging of musculoskeletal tumors have primarily been directed at improving spatial resolution and imaging times. These advances have resulted in improved definition of the extent of tumor, but they provide little if any information regarding the potential behavior of the tumor. Recent work with positron emission tomography with [F-18]-fluorodeoxyglucose (FDG PET) shows promise in grading of soft-tissue sarcomas and in predicting the biological behavior of these lesions. FDG PET imaging is based primarily on tumor glucose metabolism. Early studies suggest that it may play an important role in grading soft-tissue neoplasms and may thus affect patient management.21

Although the standard types of imaging (radiography, CT, ultrasound, and MRI) all show promise for incremental improvements over the next decade, molecular imaging has the potential to revolutionize tumor imaging and detection unlike any method available in the past. Imaging at the molecular level will detect tumors based on the expression of tumor-associated enzymes. An example of an enzyme currently used in clinical practice is the prostate-specific antigen used to detect prostate carcinoma at an early and sometimes clinically undetectable stage. Molecular imaging will rely on specific molecules as the source of contrast. Vast improvements in speed and resolution of the conventional imaging methods are essential for molecular imaging to realize its full potential. Potential benefits of molecular imaging may include monitoring response to treatment, early detection of disease, and recurrence following resection.

The current modalities available to the clinician for the evaluation of musculoskeletal neoplasia have improved tumor staging and have significantly contributed to limb salvage surgery and patient outcome. The careful use and interpretation of these studies will guide the clinician to a reasonable differential diagnosis prior to biopsy and will serve as an indispensable guide to planning surgical management. Consequently, an understanding of the basics of radiographic interpretation and the imaging characteristics associated with different neoplasia is an important tool in the armamentarium of the practitioner.

References