CHAPTER 2

Evaluation of the Patient
D. Imaging of Rheumatologic Diseases

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- Conventional radiographs are the initial imaging agent of choice for most rheumatic conditions. For many diagnoses, no additional radiologic studies are required.
- Trabecular bone and small bone erosions are visualized well by conventional radiography.
- Weight-bearing views of the knees are important in the evaluation of significant knee osteoarthritis.
- Computed tomography (CT) is superior to conventional radiographs in the assessment of certain joint conditions, including many cases of tarsal coalition, sacroiliitis, osteonecrosis, and sternoclavicular joint disease.

Imaging techniques may aid in making diagnoses, permit objective assessments of disease severity and response to treatment, and promote new understandings of disease processes. Imaging modalities that are valuable in rheumatology include radiography, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, radionuclide imaging, arthrography, bone densitometry, and angiography.

A basic knowledge of the merits and limitations of these techniques is essential in selecting the most appropriate and cost-effective imaging. In the discussion to follow, high spatial resolution will indicate excellent ability of an imaging modality to demonstrate fine bone detail and to detect small calcifications. High contrast resolution will indicate excellent ability to distinguish different soft tissue structures. Techniques such as conventional radiography have good spatial resolution. MRI generally has best contrast resolution among current imaging techniques. This chapter reviews the basic imaging techniques with regard to their spatial and contrast resolution (which determine the degree to which individual structures are visualized), radiation dose to the patient, availability, and specific uses in assessing musculoskeletal signs and symptoms.

2D-1. CONVENTIONAL RADIOGRAPHY

Conventional radiographs are the starting point for most imaging evaluations in rheumatic disorders, even when studies such as MRI are expected to follow. The cost is low and spatial resolution is very high, permitting good visualization of trabecular detail and tiny bone erosions. When necessary, resolution can be enhanced further by magnification techniques and film-screen combinations optimized for detail. However, contrast resolution is poor compared to that obtainable with CT and MRI. This limitation is especially noticeable when trying to evaluate soft tissues. Although plain radiography is a useful tool to assess the effect of a soft tissue mass on nearby bone and to detect calcification within
soft tissue, other techniques should be employed if optimal soft tissue imaging is required.

Examination of peripheral structures, such as the hands and feet, delivers a low radiation dose to the patient. Serial studies of the extremities can be performed without concern about excessive radiation exposure. Studies of central structures, however, such as the lumbar spine and pelvis, expose patients to high radiation doses. Close proximity to the gonads and to bone marrow increases the potentially detrimental effects to the patient. Whenever possible, the pelvic region of pregnant or potentially pregnant women should not be exposed to x-rays, and radiation to children should be minimized stringently. When such studies are necessary in these patients, radiation physicists can calculate the minimum radiation dose required for the imaging study. These same basic principles apply to all other x-ray imaging techniques.

Conventional radiography is widely available and convenient. Moreover, a vast fund of knowledge about plain radiographic findings in various rheumatic diseases is available (Figures 2D-1–2D-3). In many cases, simple, low cost imaging may provide all the information necessary to make clinical decisions. If the plain radiograph of the shoulder shows upward subluxation of the humeral head so that it contacts the undersurface of the acromion, one can be quite certain that the rotator cuff is torn with atrophic musculature, and likely very difficult to repair (Figure 2D-4). This may argue against a decision to undertake surgery. If surgery is contemplated, however, then MRI can confirm the large size of the rotator cuff tendon tear, the extent of muscle atrophy, and evaluate the state of the biceps tendon and articular cartilage in such cases.

Knee radiographs are useful in cases of advanced arthritis, when they may demonstrate complete loss of knee joint cartilage and bone-on-bone contact. This marks the end point for useful arthroscopic and medical treatment of knee arthritis and time to consider joint replacement. Weight-bearing views are necessary because hyaline cartilage loss is deduced from the degree of apposition of the bony surfaces. In this regard, the flexed posterior–anterior (PA) standing radiograph is often more useful than an anterior–posterior (AP) view in full extension, as the flexed view images the portion of the articular surface subject to the greatest wear (Figure 2D-5). However, for earlier stages of arthritis, MRI is important for detection of small focal articular cartilage defects that may potentially be treated with recently developed surgical techniques.

2D-2. DIGITAL RADIOGRAPHY

Computed radiography uses a photosensitive phosphor plate to create a digital image, rather than the analog image of conventional radiography. At present, computed radiography images are utilized at most centers. The resolution is adequate for many routine joint evaluations and can be improved by magnification, if necessary for special tasks. The radiation dose is approximately the same as for conventional radiography. Soft tissue is better visualized than on conventional radiographs.

Direct radiography is a technique whereby digital images are created at the time of x-ray exposure. The advantages of digital images, whether digitized conventional radiographs, computed radiography, or direct radiography, include the ability to manipulate images electronically and to display images simultaneously in several remote areas. Image manipulation permits technically excellent final images to be obtained under adverse circumstances. For this reason, computed radiography is currently popular in emergency departments and intensive care units, locations where it is often difficult to obtain optimal radiographic exposures. The ability to manipulate digital data is also useful to researchers wishing to make automated measurements on radiographs and to clinicians wishing to send images via the Internet.

The resolution of computed radiography can be improved and conventional high resolution radiographs can be converted into digital format. CT, MRI, and ultrasound images are also acquired in digital form, and are easily transported and manipulated. Digital imaging, now widely utilized, has the advantages of rapid transmission, cost-effective storage, and easy retrieval.
FIGURE 2D-2

(A) Severe rheumatoid arthritis in an elderly woman showing erosive changes and marked cartilage narrowing of wrist, intercarpal, metacarpophalangeal, and proximal interphalangeal joints. The joints involved are typical for rheumatoid arthritis. Alignment abnormalities with ulnar deviation of the metacarpals and osteoporosis are also typical. (B) Coronal STIR image of the wrist in a different patient showing multiple osseous erosions and synovial thickening, characteristic findings of rheumatoid arthritis. (C) T1 weighted coronal image showing more extensive erosions (arrow) with areas of synovial thickening. (D) Axial postcontrast fat-saturated image depicting tenosynovitis, with fluid distention of the tendon sheaths (arrow).
A 57-year-old woman with systemic lupus erythematosus (SLE) shows striking alignment abnormalities without erosions as well as periarticular osteoporosis. Similar changes are seen in the arthropathy associated with rheumatic fever (Jaccoud’s arthropathy). The cartilage destruction and synovial proliferation of rheumatoid arthritis is lacking. Early in the disorder, the alignment abnormalities can be corrected by passive positioning.

FIGURE 2D-4
(A) An 80-year-old woman with weakness and pain in the right shoulder. Radiograph shows superior subluxation of the humeral head and markedly decreased space between humeral head and acromion. (B) Oblique–coronal STIR MRI image shows similar decreased distance between the acromion and humeral head, as well as a complete rotator cuff tendon tear. (C) Sagittal oblique T1 weighted image demonstrating a significant degree of atrophy of the supraspinatus, infraspinatus, and subscapularis muscles. MRI findings could have been predicted from the plain radiograph and the clinical history. However, in this case the MRI provides an accurate estimation of the size of the rotator cuff tear, as well as commonly associated findings such as the status of the long head of the biceps tendon and articular cartilage. These soft tissue abnormalities cannot be assessed by plain radiography.
Compared with radiography, CT offers superior contrast resolution, but spatial resolution of CT remains inferior. CT is especially useful in specific locations difficult to evaluate by radiography, such as the sacrum. Although relatively expensive, CT is less costly than MRI. With the advent of multidetector technology capable of producing CT datasets with isotropic resolution, the spatial resolution of CT is comparable or superior to that of MRI, but its contrast resolution is inferior. Consequently, CT is not as sensitive as MRI for defining bone marrow or soft tissue abnormalities.

Computed tomography is an excellent technique for evaluating degenerative disc disease of the spine and possible disc herniations in older patients, in whom radiation dose is less critical than in young patients. CT myelography and CT with intravenous contrast enhancement are used to evaluate disc disease and other spinal processes. In general, MRI is preferred over CT for investigating disc disease (following plain radiography). For cases in which MRI is contraindicated, CT is an acceptable alternative and may be useful in circumstances where additional information about osteophytes is important. Elsewhere in the musculoskeletal system, CT is useful for evaluating structures in areas of complex anatomy where overlying structures obscure the view on conventional radiographs. Examples include tarsal coalitions not visible on plain radiographs (1; Figure 2D-6); sacroiliitis, especially that of infectious origin (Figure 2D-7); and articular collapse of the femoral head following avascular necrosis, indicating the need for joint replacement rather than a core procedure. The sternoclavicular joint, which is notoriously difficult to
see on conventional radiography, is quite visible with CT.

The radiation dose from CT is relatively high compared with a single plain radiograph of the same region, but the radiation doses between these imaging techniques are comparable when several conventional radiographic views of the same area are required.

If the correct initial data are obtained by appropriately adjusting the thickness of the collimation used and the thickness of the reconstructed slice width, images can be reconstructed satisfactorily in any plane, especially with the advent of advanced multidetector technology capable of isotropic resolution datasets. In addition to multiplanar reconstructions, three-dimensional images can be obtained, which may aid in evaluating abnormalities of the pelvis and other areas of complex anatomy. Using multidetector technology, including multiplanar reformatting, better images of joints affected by respiratory motion, such as the shoulder, can be acquired rapidly during a single breath, minimizing motion artifact.

High resolution (thin cut) CT of the lung may reveal details of disease not seen on thicker CT slices of the thorax. Thin cut CT scans have the additional advantage of not requiring intravenous contrast—often a concern in patients with rheumatic disease who have tenuous renal status. The interstitial lung disease that occurs in many patients with a variety of rheumatic conditions (systemic sclerosis, rheumatoid arthritis, inflammatory myopathy, microscopic polyangiitis) is characterized well by high resolution CT. The demonstration of “ground glass” infiltrates connotes an active process that may respond to treatment, but unfortunately this finding does not distinguish between infection, inflammation, and other conditions (2).

Multidetector spiral CT is now used increasingly as a means of excluding pulmonary emboli, a complication to which many patients with rheumatic disorders (systemic lupus erythematosus, primary antiphospholipid antibody syndrome, Wegener’s granulomatosis) are susceptible. For pulmonary thromboembolism detection, the chest is scanned rapidly following a bolus intravenous injection of contrast medium, timed so that the pulmonary arteries are opacified to optimal effect.

2D-4. MAGNETIC RESONANCE IMAGING

Because of its ability to image soft tissue structures not visible on conventional radiographs, MRI has brought significant advances to musculoskeletal imaging. The
technique derives structural information from the density of protons in tissue and the relationship of these protons to their immediate surroundings.

Magnetic resonance imaging involves changing the strength and timing of magnetic field gradients, as well as altering radiofrequency pulses and sampling the emitted energy. By altering these factors appropriately, varying amounts of T1 and T2 weighting are imparted to the images. T1 reflects the time constant for spins to align themselves with the main magnetic field of the equipment and T2 reflects the time constant for loss of coherence among spins, resulting in decay of the component of magnetization perpendicular to the main magnetic field. These relaxation times are different in different tissues, permitting optimal imaging of different tissues by selection of an appropriate mix of T1 and T2 weighting.

As a result, MRI highlights different types of tissue and metabolic states. Altering these parameters can produce radically different images of the same anatomic site. CT images, which basically map the density of tissues in a manner similar to conventional radiographs, are intuitively easier to grasp than are MR images.

Magnetic resonance imaging is more expensive than most other imaging approaches, largely because of the cost of equipment and the time required to perform the studies. In the future, more attention will probably be given to tailored, limited imaging sequences, which potentially could lower the cost. Newer, faster imaging sequences continue to be developed, which may reduce the time and cost of MRI, as well as provide dynamic studies of joint motion. MRI is free of the hazards of ionizing radiation, a major advantage in examining central portions of the body. The technique does pose some unique potential hazards, however. For example, the strong magnetic field can move metal objects such as surgically implanted vascular clips and foreign metal in the eyes, cause pacemaker malfunction, heat metal objects, and draw metal objects into the magnet. Metallic objects in the vicinity of the magnetic field can also compromise the quality of MRI images. Because of these risks and the adverse effect on imaging quality, operators must screen patients and visitors carefully. Patients suffering from claustrophobia may be unable to tolerate the procedure, which is performed with the patient positioned in a hollow tube. More open configurations for the magnet can circumvent this problem, but the quality of images produced by these devices varies. On rare occasions, a patient may experience an unfavorable reaction to one of the gadolinium-containing intravenous contrast agents used in some MRI studies. Finally, because MRI instruments can be noisy, hearing protection should be provided for the patient.

Spatial resolution using the latest MRI equipment is similar to spiral CT, but contrast resolution in soft tissues as well as bone marrow is superior among imaging modalities. Intra-articular soft tissue structures, such as the menisci and cruciate ligaments of the knee, are demonstrated clearly by MRI (Figure 2D-8). In fact, tiny ligamentous structures in the wrist or ankle can be assessed quite readily (3). The synovium can be imaged, especially using intravenous gadolinium. Joint effusions, popliteal cysts, ganglion cysts, meniscal cysts, and bursa-

FIGURE 2D-8

(A) Sagittal proton density images of the knee, depicting vertical tear of the posterior horn of the medial meniscus. (B) Sagittal proton density images of the knee. Bucket-handle tear of the medial meniscus, with “double Posterior Cruciate Ligament sign.”
tis can be imaged clearly (Figure 2D-9), and the integrity of tendons assessed accurately as well (4). One limitation of MRI is in the detection of calcifications, which present as signal voids and are therefore not as well seen by MRI by radiographic images. For example, chondrocalcinosis, important to the diagnosis of calcium pyrophosphate dehydrate deposition disease (CPPD), is demonstrated more reliably by plain radiography (Figure 2D-10). Otherwise, MRI remains the modality of choice for evaluating potential internal joint derangements.

Magnetic resonance imaging has specific utility in the assessment of:

- **Imaging Cartilage.** MRI has a negative predictive value close to 100% for the presence of meniscal tears in the knee. MRI is also a sensitive method for diagnosing labral tears of the shoulder and triangular fibrocartilage tears in the wrist.

Alterations in articular hyaline cartilage are visible on MRI. Although direct observation with arthroscopy is more sensitive to small superficial changes, refinements are being made that improve the ability of MRI to detect small articular cartilage defects (5). With recent improvements in therapy for cartilage defects, MRI provides a useful noninvasive method for quantifying cartilage loss as well as evaluating the success of surgical repair. In addition, MRI is the study of choice for evaluating osteochondritis dissecans when information is needed about whether the osteochondral fragment is loose or detached.

Recent studies have suggested that MRI may have a role in assessing responses to therapy in arthritis. For example, in rheumatoid arthritis, MRI can quantify the volume of enhancing inflammatory tissue (6). In ankylosing spondylitis, MRI may be used to assess changes over time in spinal inflammation (7). MRI has been established as the most sensitive modality for the detection of bony erosions (8; Figure 2D-11), although its specificity for early erosive changes has been reported to be low. Healthy subjects can occasionally demonstrate imaging findings suggestive of mild synovitis or erosions, indistinguishable from early rheumatoid arthritis (9). Finally, as bone marrow edema and synovitis can precede frank erosions, MRI may have a predictive role, and thus affect patient management early in the disease course (10).

- **Detecting Bony Abnormalities.** MRI is extremely sensitive to subtle bony abnormalities. In fact, microfractures due to trauma or stress—often referred to as “bone bruises”—were essentially unknown before MRI. Now, recognizing their presence is quite important. The pattern of bone bruises is also closely related to ligamentous injuries (11). Similarly, much of the pain accompanying some acute meniscal tears may be caused by associated bone marrow edema. When the edema subsides, the pain disappears, despite the persistent meniscal tear. This finding
could have important implications for therapy. One should possibly wait for the edema to resolve before attempting surgical intervention to repair or remove the meniscus. In some cases intervention might be unnecessary. MRI studies of the knee in older people often reveal asymptomatic meniscal tears. These individuals may have had pain at the time of the tear which resolved with the edema and did not cause them long-term disability.

- **Diagnosing Avascular Necrosis.** MRI is the study of choice for diagnosing avascular necrosis (AVN; Figure 2D-12). Early in the course of disease, plain radiographs show no abnormalities.
- **Evaluating Musculoskeletal Neoplasms.** MRI is also the best method for evaluating the extent of a musculoskeletal neoplasm. Plain radiographs are still the mainstay for detecting bone neoplasms.
- **Identifying Bone Infections.** MRI is highly sensitive to the presence of bone infection because of alterations in the marrow signal. Osteomyelitis cannot be detected on radiography until approximately 30% to 40% bone destruction has occurred. Thus, MRI is the study of choice for the early detection of osteomyelitis (12). Small studies have shown variable results for MRI in differentiating osteomyelitis and neuropathic arthropathy, which is very difficult with other imaging techniques.

**FIGURE 2D-11**

(A) An 82-year-old woman with a history of breast cancer and recent onset of lower back pain. Metastases were suspected. Tc MDP bone scan shows increased uptake in the sacrum and right pubic ramus, typical of insufficiency fractures rather than metastatic cancer. (B) Computed tomography scan in the same 82-year-old woman. This test demonstrates the linear nature of the healing fracture in the sacrum, adjacent to the right sacroiliac joint, lending specificity to the diagnosis suggested by the radionuclide scan.

**FIGURE 2D-12**

MRI images of a patient treated with glucocorticosteroids. T1 weighted image of hips demonstrates characteristic serpentine foci of low signal intensity within the femoral heads bilaterally, consistent with avascular necrosis.
• **Diagnosing Disc Herniation.** Following plain radiography, MRI is an excellent study of the spine and its contents in cases of suspected disc herniation, particularly in young patients, because it does not employ ionizing radiation.

• **Localizing Muscle Abnormalities, Including Inflammation-Associated Edema in Inflammatory Muscle Disease.** MRI is indicated in the assessment of muscle abnormalities for detection of potential tears and contusions. The activity of different muscles during joint motion can also be studied by noting signal changes that occur with muscle activity. In inflammatory myopathies (polymyositis, dermatomyositis, inclusion body myositis), MRI demonstrates characteristic (albeit not diagnostic) edema, and may be useful identifying sites to biopsy and following disease activity.

### 2D-5. SCINTIGRAPHIC TECHNIQUES

Scintigraphy following intravenous administration of agents such as 99m technetium methylene diphosphonate (99mTc MDP) for bone scans, 99mTc sulphur colloid for bone marrow scans, 67 gallium citrate (67Ga citrate), and leukocytes labeled with 111 indium [111In-labeled white blood cells (WBCs)] are useful for evaluating a variety of musculoskeletal disorders. These studies, similar in cost to CT, deliver a radiation dose similar to a CT scan of the abdomen. Scintigraphy is quite sensitive for detecting many disease processes, and has the advantage of imaging the entire body at once. The technique is nonspecific, however, because a number of processes may cause radionuclide accumulation. When areas of increased uptake are detected, additional studies such as radiography are often necessary to define the type of abnormality further. In clinical situations where the presence of skeletal disease is uncertain, a bone scan can be useful in excluding disease.

#### 2D-5-1. Localization of Scintigraphic Imaging Agents

99m Technetium methylene diphosphonate, the most commonly used radionuclide, accumulates in areas of bone formation, calcium deposition, and high blood flow. 99mTc sulphur colloid localizes in the reticuloendothelial system (liver, spleen, and bone marrow). 67Gallium citrate accumulates in inflammatory and certain neoplastic processes, and 111In-labeled WBCs localize in inflammatory sites, especially acute inflammatory processes.

#### 2D-5-2. Using Radionuclide Imaging to Diagnose Osteomyelitis

The 99mTc MDP triple-phase bone scan is commonly used for early detection of osteomyelitis. Images are obtained in the early vascular phase (during bolus injection of the radionuclide), intermediate blood pool phase (5 minutes postinjection), and late bone phase (3 hours postinjection). A fourth phase (24 hours postinjection) can be added to accentuate areas of increased bone uptake, during which time soft tissue background is decreased, although delayed imaging is not widely used because of its inconvenience. If necessary, the specificity of scanning can be increased by also using 67 gallium citrate or 111In-labeled WBCs. The 111In-labeled WBC scan is especially useful when osteomyelitis is suspected to be superimposed on a healing fracture or surgical incision because uptake of 99mTc MDP is increased at these sites even in the absence of infections. 111In-labeled WBC scans may also be useful in diagnosing osteomyelitis of the foot in people with diabetes. In suspected osteomyelitis of the hematopoietic bone marrow, the combination of 99mTc MDP and 111In-labeled WBC appears to be an effective diagnostic technique. Spatial localization of bone scans can be improved with single-photon emission computed tomography (SPECT), and radiographs of scan-positive areas can be used to increase specificity.

#### 2D-5-3. Other Uses of Radionuclide Imaging

Bone scans are a reasonable alternative for early detection of AVN if MRI is not available. Bone scans can also detect stress injuries such as shin splints, tendon avulsions, insufficiency fractures, and stress fractures, which sometimes mimic arthritic complaints (Figure 2D-12).

### 2D-6. ULTRASOUND

Ultrasound provides unique information by creating images based on the location of acoustic interfaces in tissue. It is relatively inexpensive, widely available, and free of the hazards of ionizing radiation. Spatial resolution is similar to CT and MRI, but this depends on the transducer. However, resolution is limited by the depth of tissue being studied; resolution is much higher for superficial structures.

One limitation of ultrasound is dependence on the operator. It is not always possible for one investigator to reproduce the results of another. Furthermore, because ultrasound has no cross-sectional orientation, it may be difficult for individuals who were not actually present during the study to interpret the images later.

In some centers, ultrasound has proved accurate in detecting rotator cuff tears. It is also excellent for
assessing fluid collections, such as joint effusions, popliteal cysts, and ganglion cysts, and can therefore be used to guide aspiration of fluid. Superficially located tendons, such as the Achilles tendon and patellar tendon, can be studied for tears.

Ultrasound is excellent for differentiating thrombophlebitis from pseud thrombophlebitis. With real-time compression ultrasonography, venous thrombosis and popliteal cysts can be identified.

Ultrasound, similar to MRI, has been shown to be much more sensitive than radiography in detection of erosions in rheumatoid arthritis (13). With amplitude color Doppler (ACD), it can demonstrate synovial hyperemia in active disease. The technique requires a skilled operator and is more effective in the examination of the metacarpophalangeal (MCP) and IP joints than the intercarpal joints, but is relatively inexpensive and convenient. It avoids the potentially uncomfortable positioning that may be necessary with MRI.

Finally, although ultrasound has been reported to be useful in the diagnosis of temporal arthritis, there is an absence of blinded studies confirming its utility for this purpose.

2D-7. ARTHROGRAPHY

Arthrography involves injecting a contrast agent into the joint followed by radiography. In conventional arthrography, the joint cavity is filled with an iodine-containing contrast medium and sometimes air. The cost is less than that of CT or MRI, and the procedure can be performed wherever fluoroscopy is available. The possibility of introducing bacteria into a joint or encountering reactions to the local anesthetic or contrast medium must be considered, but these complications are very rare.

One of the major reasons for developing arthrography was to examine structures within the joint, such as the menisci of the knee, which were not visible on conventional radiographs. Now these structures can be imaged noninvasively by MRI. However, certain important roles remain for arthrography.

Conventional arthrography, using iodine-containing contrast medium either alone or combined with air, accurately detects full-thickness rotator cuff tears (Figure 2D-13). CT scanning can be added to the air–contrast arthrogram (CT arthrography), providing an excellent study of the glenoid labrum that can be an alternative to MRI in selected patients (14).

Knee arthrography can confirm the diagnosis of a popliteal cyst, and permits injection of corticosteroids at the same time. It is an alternative for evaluating the menisci in patients who are claustrophobic or whose size precludes MRI examination (Figure 2D-14).

Wrist arthrography is excellent for evaluating the integrity of the triangular fibrocartilage, ligaments between the scaphoid and lunate, and ligaments between the lunate and triquetrum (15). Some clinicians prefer arthrography to MRI in this situation.

**FIGURE 2D-13**

(A) Single contrast arthrogram of a normal shoulder. (B) Single contrast shoulder arthrogram of a 66-year-old man with a painful shoulder and history of injury in distant past. Contrast media fills not only the shoulder joint [as in Figure 2D-11(A)] but has filled the subdeltoid–subacromial bursa superiorly, a finding diagnostic of full-thickness rotator cuff tear.
Magnetic resonance arthrography is performed by distending a joint with a dilute solution of a gadolinium-containing contrast medium. This technique, widely studied, probably increases the diagnostic accuracy of glenoid and acetabular labral tears, as well as rotator cuff tears (16).

**2D-8. BONE DENSITOMETRY**

Bone densitometry is used primarily for evaluating osteoporosis. Two precise, accurate, and widely available techniques are dual-energy x-ray absorptiometry (DXA) and quantitative computed tomography (QCT; 17).

Dual-energy x-ray absorptiometry scans with a narrow x-ray beam that alternates energy (kilovoltage peak; KVP). A sensitive receptor detects the fraction of the x-ray beam that traverses the body at each point along the scan path. Because the absorption characteristics of bone and soft tissue vary at different x-ray energies, the amount of radiation absorbed by bone can be calculated. From this, the amount of bone in the path of the x-ray beam at any point along the scan is determined.

Dual-energy x-ray absorptiometry is relatively inexpensive and delivers very little radiation to the patient. It is thus a good choice for studies that must be repeated. Any part of the body can be studied. Standard values are available for lumbar spine and proximal femur, which are the most widely studied.

Quantitative computed tomography scans several lumbar vertebrae while simultaneously scanning a phantom containing different concentrations of bone-equivalent material. A standard curve is constructed from the concentration values versus CT attenuation, and then the bone density at any location scanned is determined from the standard curve. The cost of this study is moderate and the radiation dose fairly low, although not as low as that for DXA. One purported advantage of this technique is that trabecular bone in the middle of the vertebrae can be evaluated because overlying cortical bone and posterior elements of the vertebrae are not measured. Trabecular bone, which has tremendous surface area, is more rapidly affected during bone loss than is cortical bone.

**2D-9. ANGIOGRAPHY**

Angiography is useful in the primary diagnosis of rheumatologic disorders with vascular components. In polyarteritis nodosa, for example, demonstration of multiple small aneurysms in medium-sized arteries may be diagnostic. Similarly, in Takayasu’s arteritis, the long, smooth tapering of involved vessels—most often the subclavian arteries—is highly characteristic. Aortography with central aortic pressure measurement is also
important in patients with Takayasu’s disease, whose blood pressures in the arms and sometimes even the legs are not accurate because of proximal arterial narrowing. In Buerger’s disease, angiography reveals “corkscrew” collaterals at the levels of the hands and wrists.

2D-10. IMAGE-GUIDED ASPIRATION AND INJECTIONS

Examination of joint fluid often plays an important part in the diagnosis of arthritic conditions such as septic arthritis, gout, and pseudogout. In most cases, the rheumatologist has no difficulty in obtaining fluid using external landmarks for needle placement. In more difficult cases, aspiration using imaging guidance may prove useful. The source of the specimen can be documented by contrast injection and radiography.

Using imaging guidance to be certain of needle tip position, injection of specific joints with local anesthetic can prove whether or not the joint is responsible for the patient’s pain. The injection of glucocorticosteroids for longer term relief can be directed in a similar fashion for greater precision in administration.

2D-11. IMAGING DECISIONS

Almost all imaging should begin with plain radiography, which is frequently all that is required. If additional diagnostic information is required to make clinical decisions, MRI is frequently the second imaging study. In many cases, MRI findings must be correlated with plain films because MRI does not easily demonstrate soft tissue calcifications or subtle cortical abnormalities of bone.

Recent MRI studies show that many individuals have anatomic abnormalities that are unrelated to symptoms (18). Therefore, imaging findings must be correlated with the clinical presentation. Imaging studies should not be obtained unless they have the potential to answer clinically significant questions. In the absence of clear clinical questions, imaging studies may raise more questions than they answer.

Finally, it is critically important for the clinician to work closely with the radiologist to decide exactly what information is needed from an imaging study, and then to select the technique that will supply that information. MRI provides such a wealth of information about so many structures that an exhaustive MRI study may be appropriate in a very puzzling joint condition. In other cases, a tailored, abbreviated MRI or a simpler imaging procedure may provide the specific diagnostic information in less time for less money.

REFERENCES

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