Clinical basics

Rheumatology: 3. Getting the most out of radiology

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The case

A 72-year-old man has been seeing the same physician for 2 decades, and his only complaint has been intermittent mild low-back pain over the last 8–10 years. The pain had not interfered with his enjoyment of an active life, which included golf, tennis and gardening. However, over the past year the low-back pain has increased and is particularly noticeable when the man is walking. The pain radiates to his right thigh and calf. It is not aggravated by Valsalva's manoeuvre and is relieved within 2 minutes by sitting. The man has had to give up most of his activities and can walk only 2 blocks. Over-the-counter analgesics and anti-inflammatory drugs, chiropractic, physiotherapy and massage have not provided lasting relief. His physician notices that he walks with a slightly stooped posture. The examination, including a detailed neurologic assessment, is normal except for tenderness over the L5–S1 vertebrae and quite marked restriction of lumbar spine movements.

For patients with musculoskeletal pain, imaging can aid in making or confirming a diagnosis. In some circumstances radiographs may also influence management. Imaging techniques that are important in arthritis assessment include plain radiography, computed tomography, magnetic resonance imaging (MRI), ultrasound, radionuclide imaging and arthrography; these are discussed below. Bone densitometry, another important assessment tool, will be discussed in an upcoming article on osteoporosis.

Plain radiography

Plain radiography remains a core technique because of its low cost, availability, convenience and excellent spatial resolution.[1,2] Radiography of peripheral structures (i.e., hands and feet) delivers a low dose of radiation so that serial studies can be performed without concern about radiation exposure. In contrast, radiography of the spine and thick areas of the body requires higher doses of radiation. Exposure of the gonads and bone marrow to radiation increases the potential risk of genetic mutation in oocytes or spermatozoa and of leukemia, respectively.[3] Young women should not be exposed to x-rays in the pelvic region unless it is essential, and radiologic evaluation of children should be minimal.[3]

The role of plain radiography in diagnosis

Imaging is more likely to confirm than make a diagnosis. Patient history and the physical examination should form the basis of a diagnosis and determine whether radiographs are necessary; usually, the more skilled the clinician, the less imaging will be required. Imaging studies should never be ordered without a thorough clinical examination because abnormalities found with imaging may not be the cause of the problem. For example, osteoarthritis of the hip may be reported on the basis of a radiograph, but the patient's "hip" pain may originate in the back. Similarly, osteoarthritis of the shoulder may be the radiologist's summary statement, but degen-

Review

Synthèse

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The Arthritis Society salutes CMAJ *for its extensive series of articles on arthritis. The society believes that this kind of information is crucial to educating physicians about this devastating disease.*

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erative arthritis of the acromioclavicular joint is often asymptomatic and a rotator cuff problem might be the actual source of the patient's pain.

Table 1: Rheumatologic conditons for which radiography is not required

Condition	Explanation
Osteoarthritis	Management is usually determined by amount of pain and disability, not by documenting progression on radiographs.
Gout	Radiologic findings are nonspecific early in the course of the disease. Examination of synovial fluid for crystals is diagnostic.
Early septic arthritis	Early on, soft-tissue swelling is nonspecific. Synovial fluid analysis and culture are essential.
Rotator cuff syndromes	Acute tendinitis or bursitis on clinical examination does not usually require radiography; it will not alter management.
Patellofemoral knee pain	Radiographs are usually normal in young patients. Clinical diagnosis is more important than documenting radiographic abnormalities.
Bunions	Radiographs are needed only if surgery is contemplated.
Chronic back and neck pain	Once documented, radiography does not need to be repeated unless the symptom complex changes; it should not be repeated simply because the severity of pain has increased.

Not only may newly discovered abnormalities not be the cause of the problem in question, but radiographs of patients with arthritic conditions can also appear normal. For example, patients with patellofemoral knee pain due to chondromalacia patellae will often have normal radiographs. This is particularly troublesome if the arthritic condition is serious. Radiographs of a patient with recent-onset rheumatoid arthritis, for example, will likely appear normal apart from soft-tissue swelling; however, early treatment with second-line drugs is required. Similarly, septic arthritis may destroy a joint in days, although an early radiograph will reveal only soft-tissue swelling and perhaps periarticular osteopenia.

It is difficult to define exactly when a plain radiograph should be ordered; it is perhaps easier to describe common situations in which radiologic evaluation is generally not required (Table 1). When doubt exists, a consult with a radiologist can help the physician decide if radiographs are necessary and provide assistance in assessing complicated clinical problems.

How many views?

Standard radiography provides a 2-dimensional picture of 3-dimensional bony structures. If there is a history of trauma and fracture or dislocation is suspected, the standard 3 views (i.e., anteroposterior, lateral and oblique) are necessary. However, if the purpose of the examination is to check for erosions in the hands of a patient with rheumatoid arthritis, either as a baseline assessment before second-

Table 2: Common conditions affecting joints and radiographic views helpful for diagnosis

Joint	Common diagnostic possibilities	Radiographic views to order
Hand and wrist	Osteoarthritis, pseudogout, inflammatory arthritis*	Single PA view
Elbow	Post-traumatic osteoarthritis, inflammatory arthritis	Standard 3 views†
Shoulder	Rotator cuff syndrome, inflammatory arthritis	Standard 3 views
Neck	Spondylosis, rheumatoid arthritis, physical trauma	AP, lateral and oblique views (flexion–extension views if C1–C2 subluxation considered)
Hip	Osteoarthritis, osteonecrosis, inflammatory arthritis	AP pelvis and frog-leg lateral
Knee	Osteoarthritis, inflammatory arthritis, ligament or meniscal injury, pseudogout	Standing AP and lateral
Ankle	Secondary osteoarthritis, inflammatory arthritis, "sprain"	Standing PA and lateral
Foot	Osteoarthritis, inflammatory arthritis	Standing PA and lateral
Sacroiliac	Spondyloarthritis,‡ osteoarthritis	15° cranial-angled view of the pelvis
Spine	Spondylosis, compression fracture, spondyloarthritis, diffuse idiopathic skeletal hyperostosis	AP and lateral

Note: AP = anteroposterior, PA = posteroanterior.
*Inflammatory arthritis includes conditions such as rheumatoid arthritis, psoriatic arthritis and Reiter's disease; Reiter's disease is more likely to affect the joints of the lower extremities.
†The standard 3 views are AP, lateral and oblique.
‡Includes ankylosing spondylitis, Reiter's disease, psoriatic arthritis and arthritis with inflammatory bowel disease.

Key points

- Imaging studies should never be ordered before taking a patient's history and completing an appropriate and thorough physical examination.
- Plain radiography remains the core imaging technique.
- Clinical indications will dictate which joints are investigated, which views are ordered and how images are taken.
- Generally, radiographs of the lower-limb joints should be performed with the patient in a standing, weight-bearing position.
- Repeat radiographs should not be ordered unless they will influence management decisions.
- Physicians who are unsure about which imaging technique to use for a particular problem should consult a radiologist.
- Computed tomography is useful for images of the spine and areas where the anatomy is complex.
- Magnetic resonance imaging (MRI) provides excellent soft-tissue imaging without radiation risks, but it is expensive.
- Radionuclide scans allow whole-body imaging and, if MRI is available, is often useful for identifying such bone disorders as osteonecrosis, osteomyelitis and stress fracture.
- Ultrasound can be very useful for imaging superficial nonosseous structures such as popliteal cysts, ganglions and joint effusions.

line therapy or when a change in therapy is being considered, a single posteroanterior view is usually sufficient (Table 2).

Neck radiographs are frequently requested following physical trauma. Fractures must be excluded, but because severe ligamentous injury, which causes instability, must also be considered, flexion and extension views are also required. Pain may inhibit active movement; thus, repeat radiography should be considered if the initial "dynamic" views show suboptimal movement. In other clinical situations the standard 5 cervical spine views (i.e., anteroposterior, lateral, right and left obliques and open-mouth view) may not be necessary. For example, the open-mouth view of the upper cervical spine is probably not necessary for a patient with radicular symptoms and signs in a C6-root distribution, and the oblique cervical spine views, which show the foramen through which the roots pass, may not be required for patients with no radicular symptoms.

Generally, radiographs of joints in the lower limbs should be taken in the standing position because these weight-bearing or stress views can provide additional helpful information.[4] Radiographs of the ankle taken while the patient is standing may show a narrowing of joint space (an indicator of articular cartilage damage, although only visible late in the course of disease), which may not be evident in nonweight-bearing views. Also, an angulation deformity seen in a standing view will lead the physician to suspect ankle instability (Fig. 1).

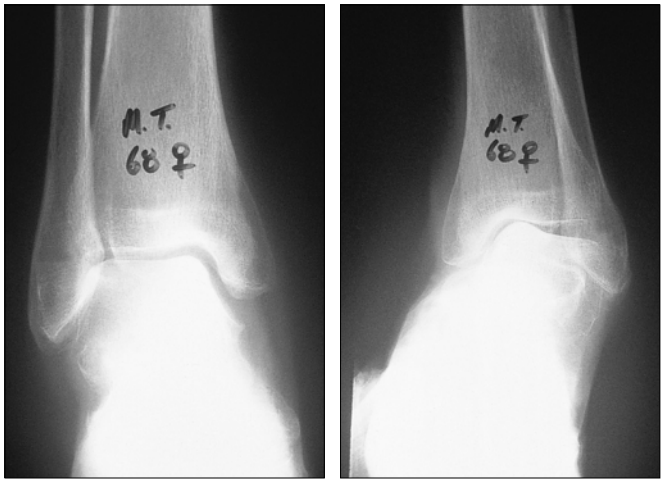


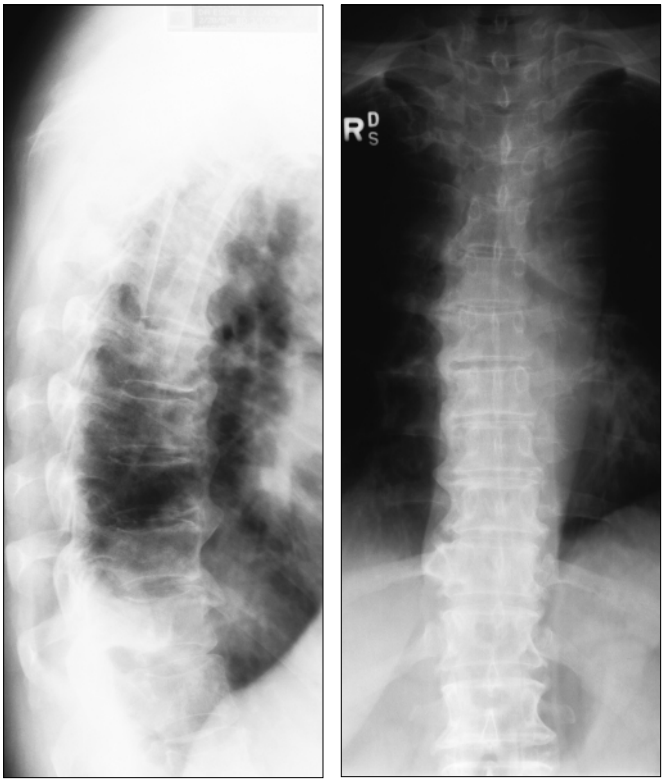
Fig. 1: Nonweight-bearing radiograph of the ankle (left) showing no major abnormalities. Standing view of the same ankle (right) showing marked loss of joint space and angulation of the tibiotalar joint.

For inflammatory arthritic conditions affecting both small and large joints (e.g., rheumatoid arthritis and psoriatic arthritis) it is usually preferable to obtain a radiograph of the affected small joints.[4] The thinner cartilage in the small joints is more likely to allow for the visualization of indicators, such as para-articular osteoporosis, cartilage narrowing or erosions. Thus, although many large and small joints are affected by polyarthritis a physician would usually order radiographs of the affected smaller joints, perhaps simple posteroanterior views of the hands and feet. In contrast, when the clinical diagnosis is osteoarthritis the physician would order radiographs of the painful joint itself (e.g., hip or knee). It is also generally helpful to obtain bilateral radiographs in these cases so the affected joint can be compared with the normal joint on the other side. If 1 of the spondyloarthritides is suspected, radiographs of the sacroiliac joints might be obtained because this is the most common and most important early finding in ankylosing spondylitis. Involvement is less consistent in the other seronegative spondyloarthropathies, however.[4]

Common radiographic findings associated with specific conditions

Rare is the condition, such as that of diffuse idiopathic skeletal hyperostosis (Fig. 2), where radiographic findings are pathognomonic; for most forms of early arthritis radiographic results are nonspecific.

Radiographic abnormalities can prove useful in confirming some diagnoses, however (Table 3 and Fig. 3). Even with a



Courtesy of Deanna Simmons

Fig. 2: Radiograph of the thoracic spine of a 65-year-old woman with diffuse idiopathic skeletal hyperostosis. Note complete bridging ("candle wax dripping") of disc spaces by osteophytes involving the anterior longitudinal ligament on the lateral view (left). On the anterior view (right) changes are more prominent on the right side of the midportion of thoracic spine, as is typical in this disorder.

condition such as gout, where visible radiographic indicators occur only late in the disease course, occasionally a patient believed to have chronic rheumatoid arthritis will be correctly diagnosed with gout on the basis of suspicions raised by the radiographic evidence (see Fig. 3E); the para-articular osteoporosis and joint-space narrowing seen with rheumatoid arthritis are absent with gout, and the erosions tend to be removed from the joint and may have an overhanging edge (unlike the more open erosions seen with rheumatoid arthritis).

Conversely, an impressive radiographic finding does not necessarily establish a diagnosis. For example, chondrocalcinosis (i.e., calcium pyrophosphate dihydrate in articular hyaline or fibrocartilage) is often present in pseudogout, but joints with chondrocalcinosis may also become septic or develop gout. Only synovial fluid tests can distinguish between gout, pseudogout and septic arthritis. However, hydroxyapatite (basic calcium phosphate), which is most commonly present as calcific periarthritis (e.g., shoulder), is not detected on conventional synovial fluid analysis but may be seen on a radiograph.

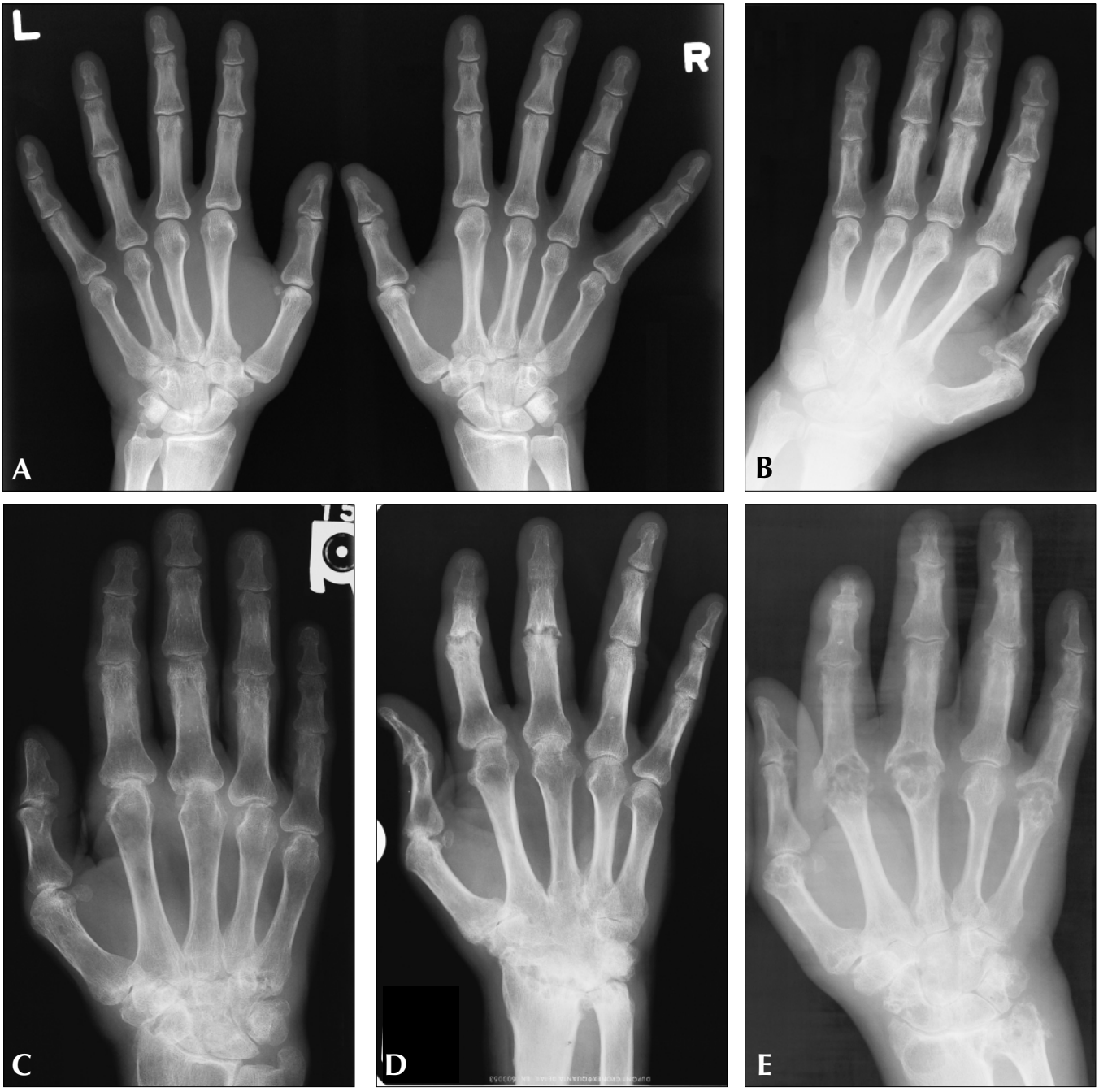
The role of radiography in management

Although radiographs can provide information that is useful in making management decisions, many radiographs ordered for this reason, particularly repeat radiographs, are unnecessary. For example, for a patient with a long history of low-back pain, which has increased in severity but not in character and distribution (i.e., a new diagnosis is not being considered), repeating the radiograph will rarely alter management. Similarly, the pain and functional disability experienced by a patient with osteoarthritis of the hip, and not

Table 3: Radiologic features and joints involved in common rheumatological conditions

Diagnosis	Radiologic features	Commonly involved joints
Osteoarthritis	Osteophytes, joint-space narrowing, bony cysts and bony sclerosis	1st CMC, DIP, PIP, knee, hip, MTP, apophyseal (facet) joints of the cervical and lumbar spine
Rheumatoid arthritis	Soft-tissue swelling, para-articular osteoporosis, joint-space narrowing, marginal erosions	All of the small and large peripheral joints can be affected with the exception of the 1st CMC and DIP joints. C1–C2 subluxation of the neck can occur.
Psoriatic arthritis	Fusiform (sausage) swelling, periosteal reaction, bone resorption of joints	Similar to rheumatoid arthritis, except the DIP joints are frequently involved and para-articular osteoporosis is less common.
Pseudogout	Chondrocalcinosis	Wrist, knee
Gout	Late erosion with overhanging edge, so-called 'rat bite'	MTP, ankle including midtarsal, knee
Spondylitis*	Sacroiliitis, syndesmophytes	Sacroiliac, lumbar spine
Spondylosis	Osteophytes, disc-space narrowing	C5–C6–C7, L4–L5–S1
DISH	Flowing calcification in the anterior longitudinal ligament of the spine, ossification of entheses	Thoracic spine

Note: CMC = carpometacarpal, DIP = distal interphalangeal, PIP = proximal interphalangeal, MTP = metatarsophalangeal, C = cervical, L = lumbar; S = sacral, DISH = diffuse idiopathic skeletal hyperostosis
*Spinal changes may also be seen in Reiter's disease, psoriatic arthritis and arthritis with inflammatory bowel disease.



Courtesy of Ross Hill

Fig. 3: Selected radiographs of the hand. A. Normal hands. B. Left hand of a 74-year-old man with soft-tissue swelling of wrist, metacarpophalangeal and proximal interphalangeal joints showing juxta-articular osteoporosis, subluxation and mild cartilage loss of the 1st metacarpophalangeal. Suggestive of: inflammatory arthritis; diagnosis: early rheumatoid arthritis. C. Advanced destructive arthropathy involving wrist and metacarpophalangeal joints in particular. Note juxta-articular osteoporosis, cartilage loss and erosions in this woman with rheumatoid arthritis. D. Advanced destructive arthropathy (as in B), but with proximal and distal interphalangeal joint involvement. There is fusion of the wrist, interphalangeal joint of the thumb and distal interphalangeal joints; distal interphalangeal fusion, in particular, is typical of advanced psoriatic arthritis. E. Advanced destructive arthropathy in which the multiple "punched out" lesions are tophi. Lack of juxta-articular osteoporosis is typical of gout. F. Chondrocalcinosis in wrist, likely due to calcium pyrophosphate deposition. Although most cases of pseudogout are idiopathic, degenerative-type changes in 2nd and 3rd metacarpophalangeal joints are typically seen in hemochromatosis, as in this patient. G. Resorption of terminal tufts with calcinosis about the 4th proximal interphalangeal joint in a person with scleroderma. H. Cartilage narrowing, bony sclerosis and osteophytosis in the interphalangeal joint of the thumb and distal interphalangeal joints, entirely consistent with Bouchard's and Heberden's nodes, respectively, and a clinical diagnosis of osteoarthritis.

any deterioration observed in radiographs, should be used to indicate whether hip surgery should be considered. However, for the patient with rheumatoid arthritis, radiographic evidence of advancing erosive disease may well influence the choice of second-line agents.

Other imaging techniques

Although new imaging techniques have improved diagnosis and management, many are costly (see Table 4) and not readily accessible to all.

Computed tomography

Computed tomography, a cross-sectional imaging technique, provides a detailed evaluation of tissues and structures without the superimposition of images. Although higher doses of radiation are typically used for computed tomography than for a single plain radiograph, modern scanners now use lower doses. In terms of showing soft-tissue changes, this technique is superior to plain radiography but inferior to MRI; however, computed tomography is also less expensive and more readily available than MRIs.

Computed tomography is helpful for assessing areas where anatomy is complex or where there are overlying structures. It is particularly useful in imaging the spine — bony impingement on the spinal canal and neural foramina can be visualized with this technique. Tarsal coalition, sacroiliitis, osteonecrosis of the femoral head, osteochondral lesions, loose bodies, occult fractures and arthritis of the sternoclavicular joint are also well demonstrated. For example, standard 2-dimensional radiographs of patients with isolated anterior and posterior osteoarthritis of the hip may be normal, but the clinical diagnosis will be revealed by computed tomography (Fig. 4). This imaging technique can also be combined with myelography or intravenous contrast enhancement to evaluate disc disease.

Magnetic resonance imaging

MRI is a superb technique for viewing soft-tissue structures. However, the cost of the equipment and its upkeep and the time required to perform the procedure make it the most expensive imaging technique currently used; the costs have been dropping, however. Although MRI does not use ionizing radiation, other hazards arise from the magnetic field's ability to move small metal objects such as surgical clips or metal fragments that may have penetrated the eye. In addition, MRI cannot be used for patients with electrical-current implants (e.g., pacemakers, defibrillators, insulin pumps), and rarely, patients may have an adverse reaction to gadolinium, a contrast-enhancing agent.

The unparalleled soft-tissue resolution of MRI permits the evaluation of joint effusions, Baker's (popliteal) cysts, ganglions, bursitis and the integrity of tendons and ligaments. Its ability to reveal the menisci and ligaments of the knee has made it a primary method for evaluating internal derangement of that joint. It is an excellent technique for detecting osteonecrosis (avascular necrosis), localized osteomyelitis and soft-tissue and bone neoplasms and for evaluating spinal dis-

ease, including disc disorders. MRI is particularly useful in young people for whom exposure to ionizing radiation may be especially undesirable. The unparalleled resolution can also expose various anatomic "abnormalitites," such as lumbar disc protrusions that are unrelated to the clinical symptoms.[1]

Radionuclide scintigraphy

Radionuclide scintigraphy permits the imaging of the whole body at a cost and a radiation dose that approximates that of a CT scan of the lumbar spine (Table 4).[1] It is considered nonspecific because if an abnormality is detected additional evaluation is often required to confirm a diagnosis. Technetium-99m methylene diphosphonate bone and joint scintigraphy has proved to be useful in detecting osteomyelitis, stress fractures, shin splints and tendon avulsions, as well as metastases and Paget's disease. When MRI is not readily available, bone scintigraphy is an excellent method for detecting osteonecrosis. However, radionuclide scintigraphy to assess inflammatory joint disease has been disappointing and is no longer widely used.

Other radionuclides used for scintigraphy include gallium-67 citrate and indium-111 leukocytes. Gallium-67 citrate accumulates in inflammatory lesions and certain neoplasms, and an indium-111 leukocyte scan can be used to identify osteomyelitis, especially at a site that would take up technetium-99m methylene diphosphonate in the absence of infection (e.g., fractures or surgical incision).

Table 4: Approximate relative costs* of various imaging techniques

Technique	Site	Relative cost
Plain radiography	Hand (3 views)	1
	Knee (3 views)	1
	Lumbar spine (3 views)	2
Ultrasonography	Knee	2
Arthrography	Knee	4
Radionuclide scintigraphy	All joints	7
Computed tomography	Lumbar spine	8
Magnetic resonance imaging	Knee	18
	Lumbar spine	20

*Costs vary with jurisdiction; these numbers are intended only as a rough guide. For example, the cost of ultrasound examination of a knee is roughly double and that of an MRI is about 18 times the cost of plain radiography.

Ultrasonography

Ultrasound is inexpensive, more widely available than MRI and, like MRI, does not involve ionizing radiation. It can provide excellent spatial resolution of superficial structures, but its efficacy depends on the skill of the operator. Fluid collections such as Baker's (popliteal) cysts, ganglions and joint effusions are identified extremely well, and superficial tendons such as the rotator cuff, Achilles and patellar tendons can be studied for tears. This technique is excellent for guiding joint aspiration or injecting difficult-to-reach joints such as the hip. Some diagnostic information can be obtained with ultrasound-guided injections of local anes-

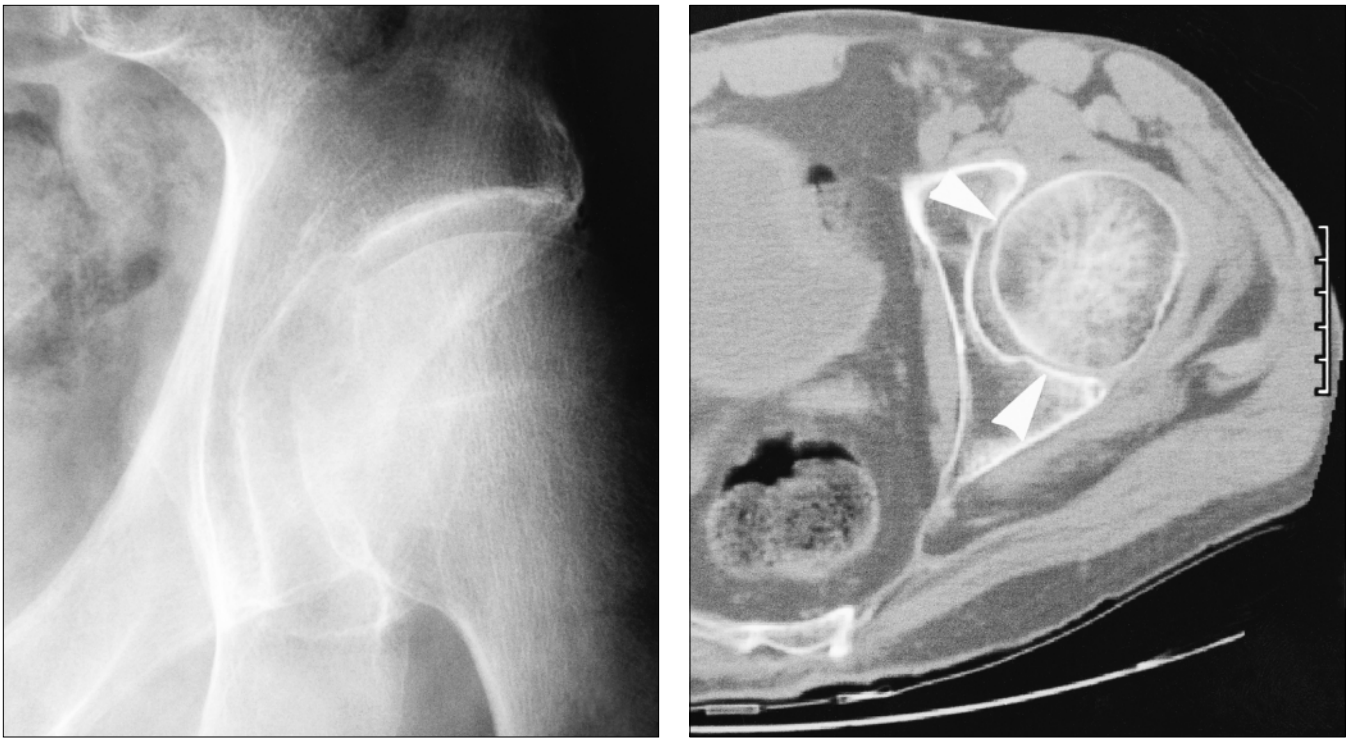


Fig. 4: Standard radiograph showing no significant arthritis in the hip (left). Computed tomography scan (right) showing marked anterior and posterior joint-space loss (arrow heads) indicative of osteoarthritis.

thetic into a joint to confirm that pain is actually arising from the joint identified by the patient.

Arthrography

Arthrography involves filling a joint cavity with a radioopaque contrast medium or air. It is less expensive than computed tomography or MRI but is uncomfortable for the patient, and results are not easily interpreted without considerable experience. It is therefore used less frequently. For people who are claustrophobic, large or are unable to undergo MRI, or when MRI is not available, joint arthrography can be used to detect internal derangements of the knee; MRI is preferable, however. Arthrography can also be useful in assessing rotator cuff tears and derangements of the wrist.

Returning to the case

The patient has radicular and claudication symptoms and walks in a slightly flexed position. These findings are typical of spinal stenosis. A normal neurologic examination is not unusual in this case. It is possible that if the patient is made to walk long enough, he would develop pain and neurologic abnormalities could be identified. Plain radiographs of the lumbar spine reveal degenerative disc disease at L3–L4, L4–L5 and L5–S1, with vertebral osteophytes and osteoarthritis of the apophyseal (facet) joints at the same levels. This suggests significant multilevel degenerative disc disease and osteoarthritis, which is also compatible with the working diagnosis. Computed tomography of the lumbosacral spine reveals severe spinal stenosis at L4–L5. The radicular symptoms suggest that surgery may be of benefit; the physician explains that quality-of-life issues must be considered when deciding whether to have surgery but recommends surgery to the patient at this time.

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