MAGNETIC RESONANCE IMAGING (MRI) vs COMPUTED TOMOGRAPHY (CT): CLINICAL APPLICATIONS IN THE FOOT AND ANKLE

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INTRODUCTION

Diagnostic imaging has a prominent role in the evaluation of musculoskeletal disease of the lower extremity. Two relatively new modalities, computed tomography (CT) and magnetic resonance imaging (MRI), offer previously unobtainable multi-plane visualization of the complex anatomy of the foot and ankle. With the increasing availability and clinical experience, and the subsequent improved cost-effectiveness of these techniques, the practicing physician must be aware of their clinical applications. Further, since patients generally must be sent to a hospital, imaging center, or other such facility for examination, the practitioner must be able to select the technique best suited for the clinical question he wishes to have answered.

The purpose of this paper is to discuss the differences between computed tomography (CT) and magnetic resonance imaging (MRI). An understanding of the basic principles and the normal anatomic structures visualized will be discussed for each method of imaging. Based upon this overview, the clinical indications and the preferred modality in specific pathologic situations will be highlighted.

BASIC PRINCIPLES/TECHNIQUES

An understanding of the basic principles and techniques involved in the operation of both computed tomography (CT) and magnetic resonance imaging (MRI) is prerequisite to their interpretation and to understanding their unique anatomic features. With both techniques, it is imperative that the referring physician provide the radiologist performing the study with a brief history and physical report along with the clinical question to be answered if an optimal study is to be obtained.

Computed Tomography (CT)

Computed tomography (CT), like conventional radiography, utilizes high-energy ionizing radiation to produce images. However, unlike conventional radiography, CT scanning focuses the ionizing radiation in the form of narrow beams to create a series of "slices" or "profiles" which are then reconstructed by a computer to provide cross-sectional images of the area examined. In this manner, cross-sectional images are provided with minimal superimposition of surrounding body structures. When ordering a CT scan for the evaluation of a suspected area of pathology, several variables should be considered including: 1) the plane(s) of imaging, 2) tissue densities, 3) section thickness, and 4) foreign materials.

In general, cross-sectional images can be obtained with CT in two basic planes of the foot and ankle: coronal (frontal) and axial (transverse). To create images in the coronal (frontal) plane, the patient lies supine with the knees flexed and the feet placed flat on the scanner table. To create axial (transverse) plane images, the patient lies supine with the knees extended and the feet oriented superior and perpendicular to the legs. With CT scanning, it is not usually possible to obtain direct longitudinal (sagittal) plane images. Longitudinal (sagittal) plane images can be synthesized by the computer by reformatting images taken in the coronal (frontal) or axial (transverse) planes.

During the construction of images, differences in tissue density can be highlighted by using soft tissue or bone "windows" (Fig. 1). Soft tissue pathology is best seen through a soft tissue "window" and osseous pathology is best visualized with a bone "window." In cases of suspected pathology involving both soft tissue and osseous structures, or in cases in which the clinician is unsure, images should be ordered with both soft tissue and bone "windows."

Further, the thinnest possible sections should be taken to obtain the images. Solomon et al. (1,2) recommend sections 1.5-2.0 mm thick to optimally display the complex anatomy and pathology of the foot and ankle. The quality of reformations in other planes (e.g., longitudinal (sagittal) plane reformations) depends on the thinness of the original image sections. Thus, high-quality reformations require very thin-section imaging in the original plane studied.

HIGHEST DENSITY

Cortical bone
Cancellous bone
Muscle
Nerve
Tendon
Ligament
Subcutaneous fat
Air

LOWEST DENSITY

Fig. 1. General densities of anatomic structures on CT images. It should be noted that variance will occur with changes in window settings.

Finally, foreign materials must be considered when ordering CT scanning. Images can be taken with external dressings and casts intact, but may necessitate a specific scanning plane due to positional restrictions. For example, a below-knee cast will necessitate the use of the axial (transverse) plane scanning position. The quality of the images will not be effected by these external dressings and/or casts. However, the quality of CT images is effected by internal fixation devices. Metallic internal fixation hardware causes significant degradation of CT images.

Obviously, when considering a CT scan of the foot and/or ankle, it is extremely important to have complete and accurate communication between the physician requesting the scan and the radiologist who will perform the scan. When ordering a scan, the region of suspected pathology, the particular plane(s) of sectioning, the tissue "window(s)", and the size of the section slices are study variables which should be discussed.

Magnetic Resonance Imaging (MRI)

Unlike CT scanning and conventional radiography, magnetic resonance imaging (MRI) uses low-energy radio waves to produce images. In the simplest terms, four components are necessary for the production of the images: 1) a strong static magnetic field, 2) hydrogen nuclei (i.e., the physical sample or part to be examined), 3) coils to transmit and receive low-energy radio frequency pulses, and 4) magnetic gradients (i.e., small magnetic fields with known, carefully controlled spatial variation). As with computed tomography (CT), the image is reconstructed from observed radio frequency waves or pulses by the use of a computer (3).

Nuclei with an odd number of protons when placed in a strong external magnetic field will display nuclear magnetism and align directly with or against the magnetic field. At room temperature, protons can intraconvert between alignment with the magnetic field and against the magnetic field. This phenomenon is known as resonance. The simplest atom that has these characteristics is hydrogen (one proton in its nucleus) and it is most commonly studied with clinical MRI due to its abundance in living tissue. Both water and fat have very high concentrations of hydrogen.

In addition to resonating like tiny bar magnets, protons can be made to precess or wobble in a strong magnetic field. Protons can be made to precess in phase by applying radio frequency waves or pulses. This is an unstable high-energy state that can be maintained only as long as the radiofrequency pulse is present. When protons precess in phase a strong signal is generated and can be detected by a radiofrequency receiver. The protons get rapidly out of phase and can subsequently be rephased with another type of radiofrequency pulse (4). In this manner a measurable signal is created and detected by the radio frequency receiver. A computer then interprets the information and creates the image. With MRI, direct images may be obtained in virtually any plane with slice thicknesses as small as 2.0 mm.

Most of the clinical MRI performed today is with the patient in a homogeneous high-strength magnetic field. Magnetic strength fields used today vary from 0.3 to 1.5 Tesla. For comparison, the earth's magnetic field at the surface of the United States of America is roughly 0.00005 Tesla (5). Images are created by placing the part to be examined in this magnetic field and then applying radiofrequency waves to the part in specific pulse sequences. A process called spin-echo imaging where 90-degree radiofrequency pulses are followed by varying sequences of 180 degree radio frequency pulses are used and comprise a pulse sequence. The pulse sequence is repeated numerous times to acquire sufficient information to generate an image (6).

Useful descriptive terms, which are common in MRI parlance to describe pulse sequences, are T1-weighting and T2-weighting. T1 and T2 are tissue-specific constants which are different for each tissue. By varying the pulse sequence, a T1-weighted image, T2-weighted image, or proton thin density image may be created. Generally, a T1-weighted image demonstrates differences in T1 between tissues and is obtained with a short TR (repetition time) and short TE (echo time). A short TR means that there is generally less than 1,000 milliseconds (msec) between successive 90-degree pulses. A short TE means that there is 30 msec or less between the 90-degree pulse and the 180-degree pulse.

A T2-weighted image demonstrates differences in T2 between tissues and is obtained with a long TR (1,500 msec or greater) and a long TE (60 msec or greater).

A proton thin density image has a long TR and a short TE. Frequently, data included with the image will list only the TR and TE values. Thus, a knowledge of TR and TE values is necessary to properly determine whether an image is T1-weighted, T2-weighted, or a proton thin density image (Fig. 2).

T1 values for tissue generally are dependent on the fat content of the tissue while T2 values for tissue are dependent on the water content of the tissue. Thus, a T1-weighted image can be thought of as simply a "fat image" and a T2-weighted image can be considered a "water image." Fat, muscle, nerve, cartilage, tendon, ligament, bone and other body tissues each have unique T1 and T2 values. On T1-weighted images, body tissues or structures containing greater amounts of fat will be most "intense" or "bright". On T2-weighted images, body tissues or structures containing greater amounts of water will be most "intense" or "bright." Consequently, virtually no signal emanates from air, cortical bone, calcifications, physeal growth plates, ligaments, tendons, and scar tissue due to their lack of significant fat or water content and low number of mobile protons. These structures will appear least "intense" or dark on both T1- and T2-weighted image (Fig. 3). Other structures will have varying "intensity" on T1-weighted and T2-weighted images (Fig. 4). The ability of flowing blood to image on MRI depends on the rate of flow. Rapidly flowing blood (i.e., blood with a velocity greater than 5 cm per second) will not generate a signal as the excited nuclei within the blood vessel have moved from the imaging plane by the time the data is collected. Subsequently, most blood vessels will appear less "intense" or dark when imaged. Slower flowing blood and areas of chronic hemorrhage or hematoma will demonstrate increased signal intensity and will appear "bright" of T2-weighted images (4).

Finally, as with CT, it is important to provide the diagnostic radiologist with background information on the clinical problem to be investigated. Ideal imaging will involve variation of pulse sequences and obtaining images which accentuate the tissue suspected of being pathologic. The optimal use of MR images depends on obtaining multiple sets of images with different pulse sequences. Used in this fashion, dramatic tissue contrast is possible.

CLINICAL APPLICATIONS -- GENERAL

Both computer tomography (CT) and magnetic resonance imaging (MRI) possess the ability to differentiate tissue typed and to provide cross-sectional anatomic imaging. However, MRI has several general advantages over CT scanning.

First, MRI does not require ionizing radiation nor contrast agents to obtain images. CT scanning does produce significant radiation exposure to the patient. The only significant hazard associated with MRI emanates from the high-strength magnetic field. Studies have shown that the magnetic field may effect magnetic aneurysmal clips and pacemakers. Thus, patients with surgically implanted aneurysmal clips or cardiac pacemakers should not be imaged with MRI (8).

The second advantage of MRI is that non-magnetic metallic implants, such as those commonly used in podiatric surgery, are generally not effected. Indeed, MRI

T1-weighted Image
"Fat Image"
Short TR (0-1,000 msec)
Short TE (0-30 msec)

T2-weighted Image
"Water Image"
Long TR (1,500+ msec)
Long TE (60+ msec)

Proton Thin Density Image
Long TR (1,500+ msec)
Short TE (0-30 msec)

Fig. 2. MR images which can be generated by different pulse sequences.

Air
Rapidly flowing blood
Cortical bone
Calcifications
Physeal growth plates
Ligaments
Tendons
Scar tissue

Fig. 3. Structures which generate virtually no signal on MRI (both T1- and T2-weighted images).

T1-WEIGHTED	T2-WEIGHTED
HIGH INTENSITY	
Subcutaneous fat	Slow-flowing blood
Cancellous bone	Infection
Slow-flowing blood	Tumor
Hyaline cartilage	Subcutaneous fat
Infection	Cancellous bone
Tumor	Muscle
Muscle	Hyaline cartilage
Scar tissue	Scar tissue
Tendons	Tendons
Ligaments	Ligaments
Physeal plates	Physeal plates
Calcifications	Calcifications
Cortical bone	Cortical bone
Rapidly-flowing blood	Rapidly-flowing blood
Air	Air
LOW INTENSITY	

Fig. 4. Relative intensities of musculoskeletal tissues on MRI. Note differences in intensity on T1- and T2-weighted images.

is preferred over CT for imaging in patients with Kirschner wires, Steinmann pins, screws, staples, and plates as only a focal absence of signal intensity is produced with MRI (9). When CT scanning is used in these patients, significant artifact is created and image quality in the area of the metallic device is poor.

Finally, MRI images can be obtained in virtually any plane. As stated earlier, CT scanning is limited to direct imaging in the coronal (frontal) and axial (transverse planes and to reformatting or indirect imaging on the longitudinal (sagittal) plane. Therefore, the longitudinal (sagittal) plane images obtained with MRI are generally superior to those obtained with CT.

The main disadvantage of MRI relates to its availability. In some areas of the country, MRI is not yet available at local hospitals and imaging centers. Also, MRI has a comparatively high cost and a greater imaging time than CT. However, when MRI offers a significant imaging advantage over CT, this generally should not be a limiting factor as CT also involves considerable cost and imaging time.

It is now becoming clear that although either MRI or CT can be used as an imaging modality in most clinical situations, there are specific imaging applications where one modality may be preferred over the other. Broadly speaking, CT is preferred for imaging cortical bone while MRI is preferred for imaging cancellous bone (i.e., medullary bone or bone marrow) and soft tissue.

CLINICAL APPLICATIONS -- SPECIFIC

Specific podiatric applications of MRI and CT can be considered logically if divided into subcategories based upon a differential diagnostic plan—congenital, metabolic, infectious, neoplastic, and traumatic applications (Fig. 5).

Congenital Applications

The most common congenital application for which these imaging modalities is utilized is in the evaluation of tarsal coalitions. CT scanning in the coronal (frontal) plane with osseous windows has become the modality of choice for evaluating the subtalar and midtarsal joints

Congenital Applications
- Tarsal coalitions

Metabolic Applications
- Arthropathies
- Osteonecrosis (i.e., aseptic necrosis)

Infectious Applications
- Abscess
- Osteomyelitis

Neoplastic Applications
- Osseous tumors
- Soft tissue tumors

Traumatic Applications
- Osseous trauma
- Soft tissue trauma

Fig. 5. Specific podiatric applications of CT and MRI.

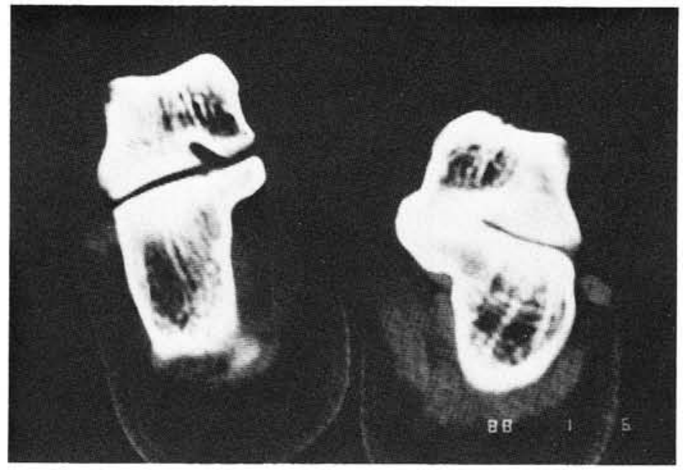


Fig. 6. Coronal (frontal) plane cross-sectional CT image of rearfoot demonstrating an osseous talocalcaneal coalition of middle facet of subtalar joint (right). Note middle facet is normal in contralateral foot (left).

when a tarsal coalition is suspected and standard radiographs are inconclusive. Coalitions can be fibrous, cartilaginous, or osseous in nature (10). Subtleties of the subtalar and midtarsal joints can best be visualized in the coronal (frontal) plane. Obviously, with osseous coalitions, CT scanning is preferred because of its ability to image cortical bone (Fig. 6). With fibrous and cartilaginous coalitions, there is usually alteration of the subchondral cortical bone structure and this will be suggested by the CT images. MRI has not been used extensively for the evaluation of tarsal coalitions. It may eventually provide better diagnostic information than CT when the coalition is fibrous or cartilaginous in nature because of its ability to more clearly image these tissues.

Metabolic Applications

Both CT and MRI can be used to assess arthritic processes. CT scanning can be used to assess the extent of bone damage but is of limited usefulness in the evaluation of bone marrow erosion, joint effusion, synovial sheath effusion, and cartilaginous irregularity or thinning because of the beam hardening and streak artifacts of surrounding dense cortical bone. MRI is particularly valuable in the assessment of these periarticular components. Thus, MRI will generally allow earlier and more accurate assessment of arthropathies.

With MRI, bone erosions are defined as areas of low signal intensity on T1-weighted images where one would usually expect the high signal intensity of bone marrow. Joint and synovial sheath effusions are seen as areas of decreased signal intensity on T1-weighted images and increased signal intensity of T2-weighted images within the joint capsule of tendon sheath (Fig. 7). Normal hyaline cartilage can be visualized with MRI and has an intermediate signal intensity between that of cortical and cancellous bone on both T1-weighted images and T2-weighted images (Fig. 8). Normal cartilage is smooth and of even thickness. Abnormal cartilage has similar image intensity to normal cartilage, but has an abnormal contour with focal thinning of loss or thickness (11).

Obviously, MRI provides an unprecedented amount of information regarding the periarticular damage of the arthritides. For this reason it is the preferred imaging modality in most arthritic conditions. Recent studies have supported this conclusion in regards to the early recognition, assessment, and evaluation of treatment response in patients with juvenile and adult rheumatoid arthritis (12,13).

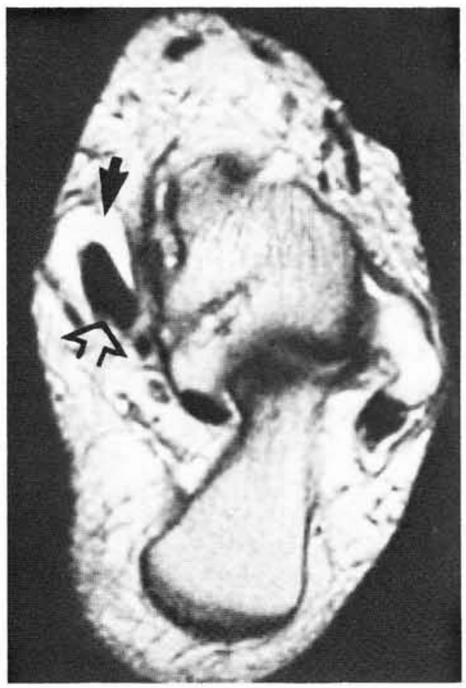
Similarly, both CT and MRI can be used to assess avascular necrosis (i.e., osteonecrosis). However, MRI is generally more sensitive to avascular necrosis and will be able to image it earlier. The hallmark of early avascular necrosis on MRI is a relatively well-defined region of decreased intensity within the medullary bone on both T1- and T2-weighted images (14,15). Although most of the research on MRI and avascular necrosis has focused on the femoral head, a case of aseptic necrosis of the talus with similar findings has been reported (16).

Infectious Applications

CT and MRI can be useful adjuncts in the assessment of soft tissue and osseous infections. Neither imaging

A

B



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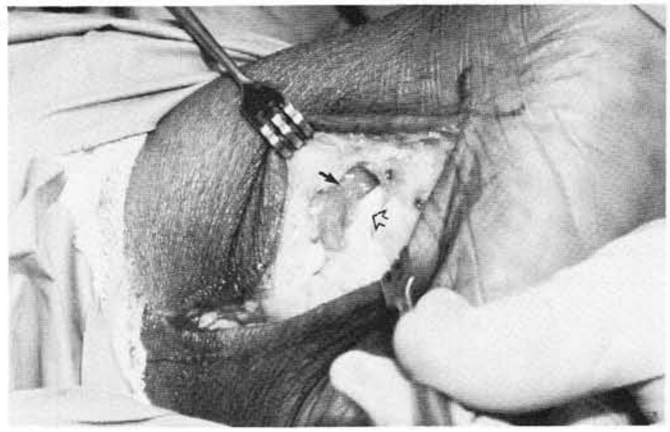


Fig. 7. Coronal (frontal) plane MR images of synovitis of tibialis posterior tendon. Tendon (open arrow); Tenosynovitis (closed arrow). A. Proton thin density image. Note low signal intensity of tenosynovitis; B. T2-weighted image. Note high signal intensity of tenosynovitis; C. Tenosynovitis of tibialis posterior tendon confirmed intraoperatively.

technique is useful for routine screening and should only be used to increase diagnostic information when other modalities are inconclusive or do not provide the desired information. Both CT and MRI can provide cross-sectional imaging which may be helpful if traditional radiographs are unable to delineate the extent of a soft tissue abscess or osteomyelitic process.

CT scanning with soft tissue and osseous windows can provide good coronal (frontal) plane visualization of the foot and ankle. This imaging plane can be of particular value in the diagnosis and evaluation of compartment infections. Areas of localized abscesses can be differentiated from surrounding soft tissue structures. CT also provides information on the presence of cortical invasion in osteitis or osteomyelitis. This can be particularly helpful in diagnosing and assessing osteomyelitis secondary to the spread of infection from contiguous areas or from direct implantation as concise evaluation of cortical bone is often critical in these cases (17). CT is capable of depicting sequestra, cloacae, involucra, and intraosseous gas (18,19).

Conversely, as in other clinical applications, CT scanning does not provide clear visualization of bone marrow due to beam hardening artifacts generated from surrounding cortical bone. This will limit its usefulness in the evaluation of osteomyelitis extending into or primarily effecting medullary bone.

MRI has proven valuable in the evaluation of soft tissue abscesses and osteomyelitis. Both T1- and T2-weighted images are needed to evaluate musculoskeletal infection. The typical appearance of a soft tissue abscess on MRI is a localized well-demarcated area of heterogenous signal alteration, usually with a decreased signal intensity of T1-weighted images and an increased signal intensity of T2-weighted images. Cellulitis and other diffuse inflammatory processes present with similar findings but with ill-defined margins.

In osteomyelitis, because of an increase in intramedullary water, the infected marrow will manifest a low signal intensity on T1-weighted images and high signal intensity of T2-weighted images. During the early stages of osteomyelitis, the margins of the infectious process within

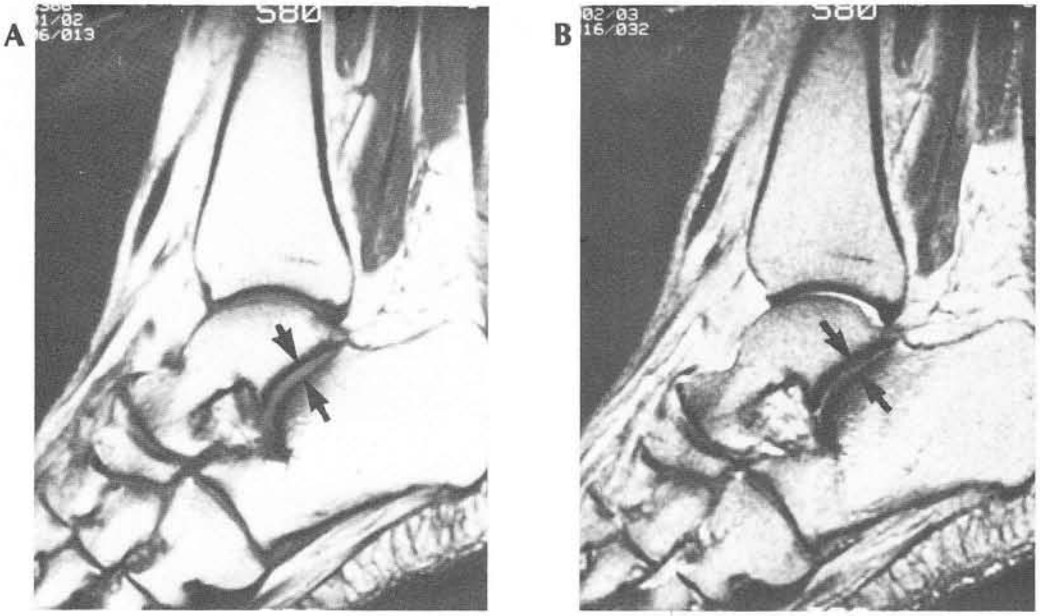


Fig. 8. Longitudinal (sagittal) plane MR images of foot and ankle. A. T1-weighted image. B. T2-weighted image. Note intermediate signal intensity of cartilage of posterior facet of subtalar joint. Cartilage is surrounded by subchondral bone (arrows which generate no signal (dark). Brighter (higher signal intensity) portions of bones are bone marrow.

bone are ill-defined. With further localized bone destruction, the margins tend to become more distinct. Sequestra and involucra consisting of cortical bone can be hard to visualize unless surrounded by exudate or soft tissue.

In septic arthritis, MRI is very sensitive in the depiction of increased joint fluid and medullary bone destruction (20). Destruction of the articular cartilage results in loss of its normal intermediate intensity signal. After the cartilage is destroyed, the septic joint is bounded only by subchondral cortical bone and the joint space may appear to have a lower signal intensity on T2-weighted images (21).

Unfortunately, other clinical conditions can present with similar findings to those of soft tissue and osseous infection. Thus, MRI is relatively sensitive but nonspecific. Indeed, a false positive has been reported where a suspected case of osteomyelitis diagnosed with MRI was proven surgically to be an effusion and tenosynovitis (22). Clinical signs of infection and other testing modalities must be used in conjunction with MRI or CT.

Neoplastic Applications

CT and MRI are now considered the standard diagnostic tests for evaluating the extent, location, and in many cases the possible tissue type of both osseous and soft tissue neoplasms.

Osseous Tumors

Both CT and MRI have a role in the evaluation of osseous neoplasms. The location, extent, matrix and morphologic appearance of an osseous lesion as visualized on standard radiographs helps to characterize it. Depending upon this information, the physician and radiologist can determine if either CT or MRI is necessary. If deemed necessary, they may be performed alone or together based upon the additional diagnostic information desired.

As previously mentioned, CT is generally superior to MRI for the evaluation of cortical bone. Therefore, CT scanning is preferred for evaluating ossification, calcification, endosteal thinning, and fine periosteal reactions. MRI is superior to CT in the evaluation of bone marrow and the surrounding soft tissues. Also, MRI allows improved pluridirectional imaging. Thus, MRI is preferred when evaluating extraosseous disease and intramedullary lesions or when multiplanal imaging is desired (23,24).

Soft Tissue Tumors

Whereas both CT and MRI have preferred indications for the evaluation of osseous tumors, MRI is usually the preferred modality for assessing soft tissue masses. MRI is superior in the detection, staging, and characterization of soft tissue tumors.

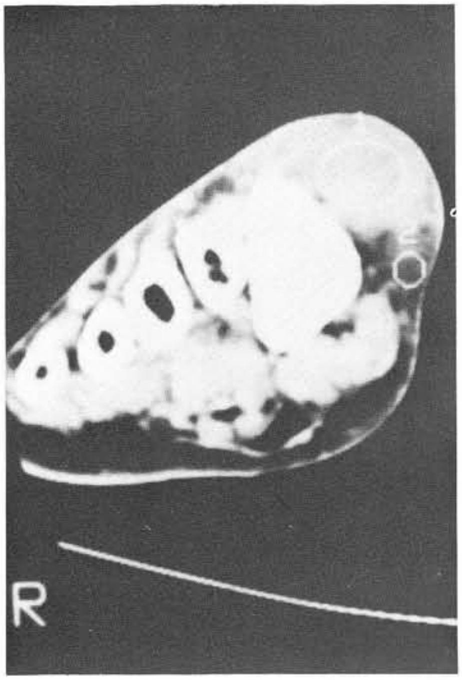


Fig. 9. Coronal (frontal) plane cross-sectional CT image of large soft tissue mass on dorsomedial aspect of foot. Note inhomogenous density of mass (difference in circled area 1 and circled area 2). Mass was found to be fibrous malignant fibrohistiocytoma.

A properly performed MRI examination can be used to confirm or exclude the presence of an abnormal soft tissue mass with significant accuracy. CT scanning can be used for the detection of soft tissue masses, but is far less accurate (25-28).

The staging and characterization of soft tissue masses is also usually superior with MRI. Benign soft tissue masses tend to have well-defined margins and relatively homogenous internal structure when visualized on either CT or MRI. Conversely, malignant tumors tend to have irregular, poorly defined margins and inhomogenous internal structure. Neither CT nor MRI can conclusively differentiate benign tumors from malignant tumors. Further, neither modality has demonstrated diagnostic efficacy for intermetatarsal neuromas (4).

When CT scans are performed for the evaluation of soft tissue masses, coronal (frontal) plane images with soft tissue windows will generally afford the most information (Fig. 9). Besides the location and extent of the mass, some determination can be made about the density of the soft tissue mass (29). However, on CT images, muscle, tendon, nerves, and blood vessels all have similar gray scale values and the contrast between them can be minimal (30).

Comparatively, the main advantage of MRI in the evaluation of soft tissue masses is the dramatic soft tissue contrast inherent in the technique (31). The appearance

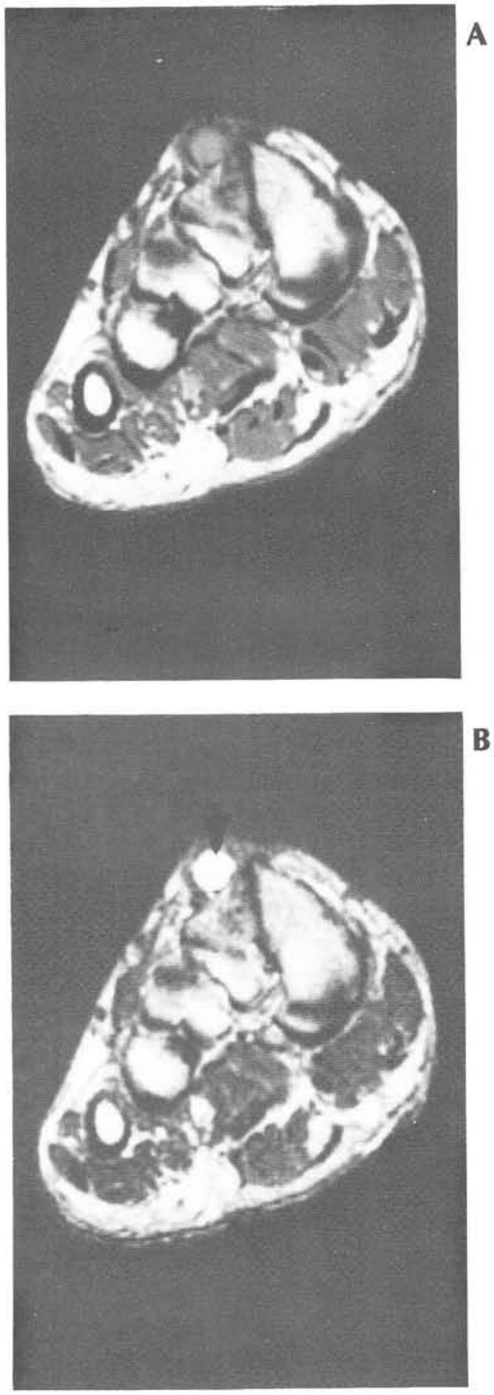


Fig. 10. Coronal (frontal) plane MR images of ganglion (closed arrow) on dorsum of foot. A. Proton thin density image. Note homogenous low intensity signal of mass. B. T2-weighted image. Note homogenous high intensity signal on mass. This pattern is typical of ganglion.

of soft tissue tumors on MRI varies with the pulse sequence selected. In most soft tissue tumors there is an augmentation of the water content in the pathologic tissue when compared to surrounding normal tissues. Therefore, on T1-weighted images, soft tissue tumors will be of low or intermediate intensity. On T2-weighted images, most soft tissue tumors will be "bright" or of high intensity. In this sense, besides being referred to as the "water image," T2-weighted images are also called "pathologic images" (Fig. 10) (6). It should be remembered though that soft tissue tumors which have abundant collagen or are more acellular in nature (e.g., fibromas) can have a similar low signal intensity on both T1- and T2-weighted images (32).

Traumatic Applications

Conventional radiographs remain the standard for the evaluation of most musculoskeletal trauma. In most cases, CT and MRI provide a supportive role providing additional diagnostic information which may not be necessary. However, in some traumatic situations CT and MRI provide indispensable information and in some situations the diagnosis itself. Again, CT scanning is generally preferred for the evaluation of problems involving cortical bone and MRI is preferred for the evaluation of other structures (i.e., cancellous bone, cartilage, soft tissue, etc.).

Osseous trauma

Because of its indirect visualization of cortical bone (i.e, cortical bone generates no signal but is visualized because of the signal intensity generated by surrounding structures), MRI offers very little information in evaluating osseous trauma although a recent report suggests it may be helpful in the diagnosis of stress fractures (33). CT meanwhile offers significant information. Using osseous windows the cross-sectional imaging available with CT can be helpful in the diagnosis or may provide more clear delineation of many fractures. Three-dimensional CT is now available and used for the cross-sectional assessment of complex fractures such as joint depression fractures of the calcaneus (Fig. 11)(34).

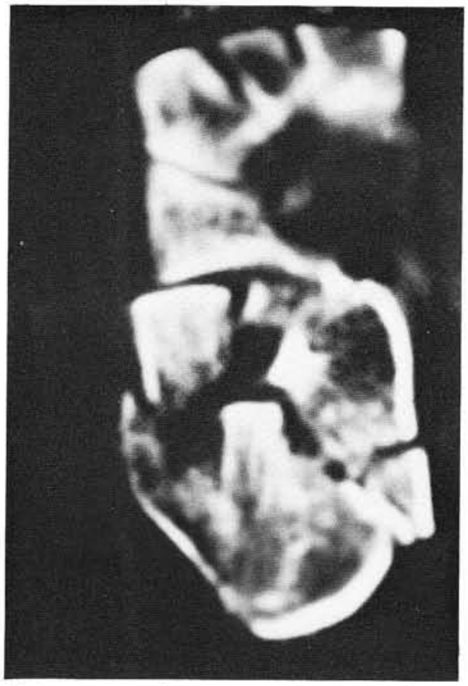


Fig. 11. Axial (transverse) plane cross-sectional CT image through rearfoot of joint depression calcaneal fracture.

Physeal Injuries

As with cortical bone, physeal growth plates are not directly visualized with MRI. Thus, CT scanning is still preferred for the evaluation of injuries to the physis when a cross-sectional imaging modality is indicated (e.g., tri-plane ankle injuries) (Fig. 12).

Osteochondral/Articular Injuries

Because of its ability to visualize cartilage, MRI is uniquely suited to the evaluation of osteochondral and other acute joint injuries. The intermediate signal intensity of hyaline cartilage on both T1- and T2-weighted images is clearly differentiated from the low intensity signal of subchondral cortical bone (Fig. 13). Larger osteochondral fractures or defects can also be depicted on CT.

Soft Tissue Injuries

MRI demonstrates soft tissue injury with superior contrast and detail than CT. Some soft tissue injuries can be visualized by CT, but in many cases even with the use of soft tissue windows, the contrast between tissue types is poor.

With MRI, hematoma formation and the imaging characteristics of the soft tissue in question are key variables in the ability of MRI to evaluate soft tissue injuries. Tendons and ligaments generate a low intensity signal on both T1- and T2-weighted images. However, they may be indirectly assessed because of surrounding soft tissues which generate greater intensity signals. Hematoma demonstrates a high intensity signal on T2-weighted images. Therefore, acute tendon or ligamentous injuries may demonstrate structural discontinuity of low signal intensity with interspersed hematoma of high signal intensity on T2-weighted images (Fig. 14). Partial tears appear as high signal intrastructural intensities on T2-weighted images. As the tendon or ligament heals, the signal generated by the hematoma and edema decreases and the low intensity structural signal predominates demonstrating the healed position and contour of the tendon or ligament. Healed partial tears may present as a focal enlargement of the structure, but generally without increased signal intensity on T2-weighted images. This imaging potential has been most commonly used in the evaluation of injuries to the tendo Achillis (Fig. 14) (3,4,14,35-37).

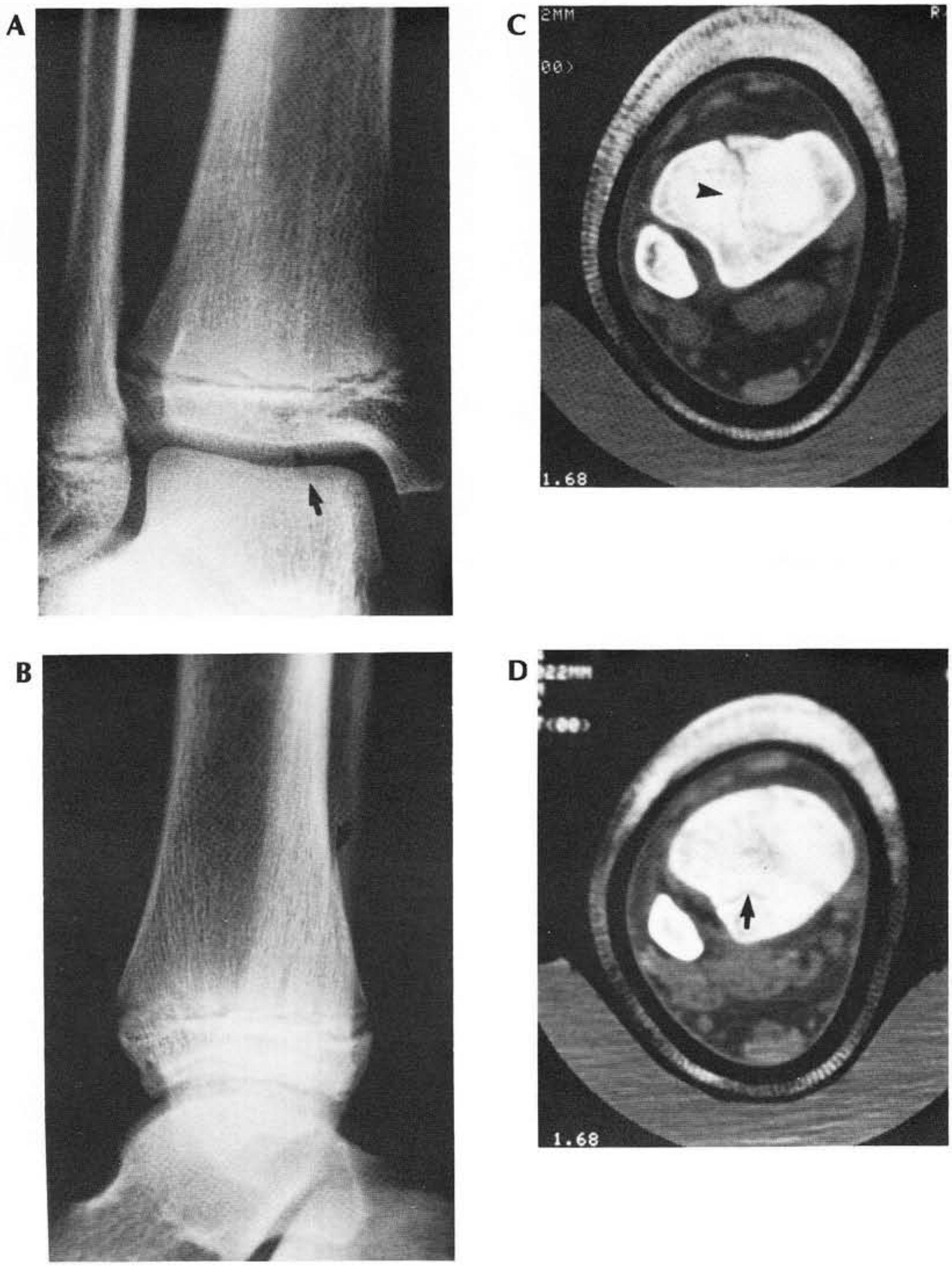


Fig. 12. Triplane ankle fracture with Salter-Harris Type IV physeal injury in 11-year old patient. This injury appears as Salter-Harris Type III injury on AP view of ankle (A), and as Salter-Harris Type II injury on lateral view of ankle (B). Multiplanar nature of this injury can be clearly appreciated with axial (transverse) CT images. Inferior to physis, fracture line extends from anterior to posterior (C). Superior to physis, fracture line extends from medial to lateral (D). Injury changes orientation at physis.

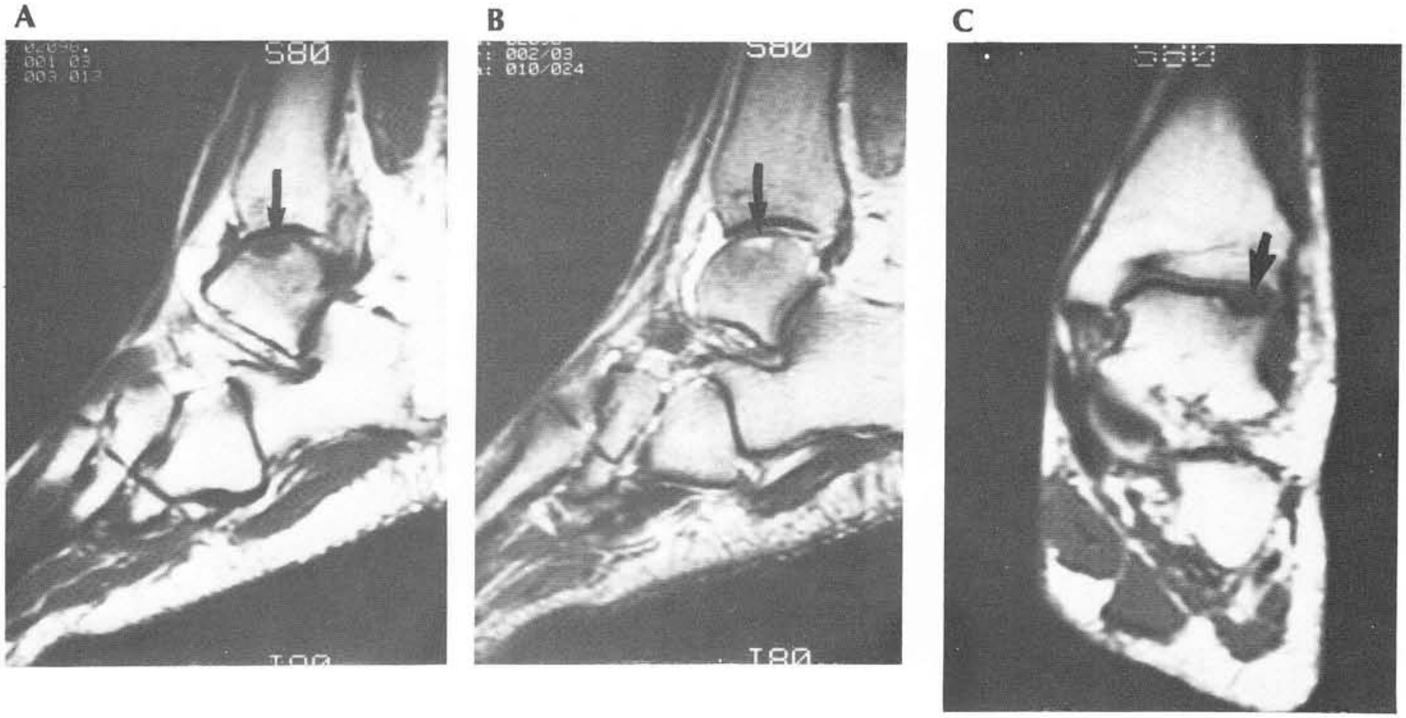
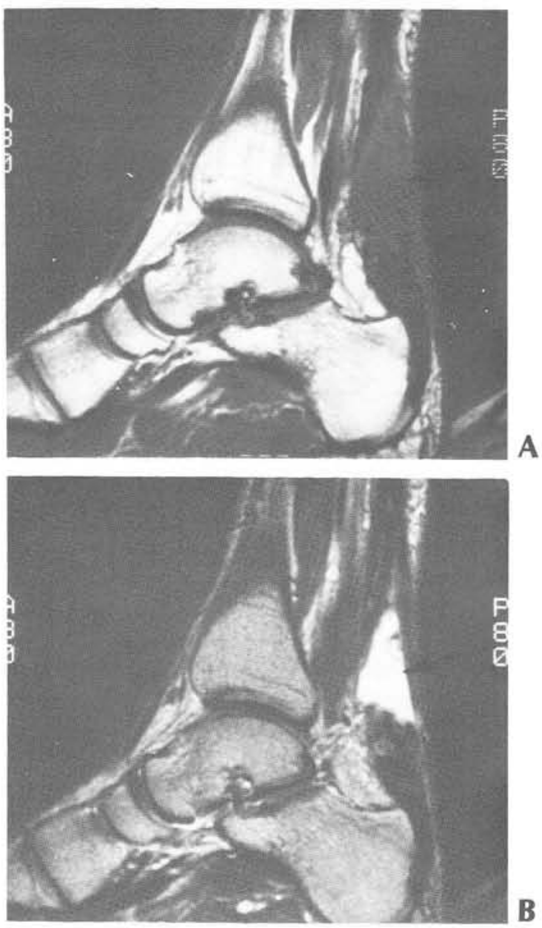


Fig. 13. MR images of transchondral fracture of talus. A. Longitudinal (sagittal) plane T1-weighted image. Note low intensity area (closed arrow) which represents defect in bone marrow of talus; B. Longitudinal (sagittal) plane T2-weighted image. Note high intensity signal area (closed arrow). C. Coronal (frontal) plane T1-weighted image. Defect is more visible on T1-weighted images as fracture is bone marrow (fat) damaging injury. Diagnosis of anterolateral transchondral fracture can easily be made with MRI.



14. Longitudinal (sagittal) plane MR images of tendo Achillis rupture. A. T1-weighted image. Deficit in tendon with hematoma (closed arrow) difficult to visualize. B. T2-weighted image. Note deficit is now easy to visualize with high signal intensity of hematoma.

Chronic ruptures can also be evaluated. A recent study compared CT and MRI in the evaluation of chronic ruptures of the tibialis posterior tendon. The accuracy in depicting ruptures was 91 percent for CT and 96 percent for MRI. MRI was concluded to be more sensitive and specific for these chronic injuries. The study further concluded that MRI provided greater definition of tendon outline, vertical splits, synovial fluid, edema, and degenerated tissue as compared to CT. CT was found to be superior in showing associated bone abnormalities such as periostitis and subtalar arthritis (38).

SUMMARY

CT and MRI can clearly delineate many important pathologic processes in the musculoskeletal system. As clinical experience and the technology of the modalities increases, further indications will become apparent. However, both of these modalities are expensive. In today's cost-conscious medical arena, one must have a clear understanding of when these imaging techniques can and should be used. Without this knowledge, overuse of the modalities is bound to occur. When the indications and applications of these techniques is understood, the studies can provide valuable diagnostic and evaluative information.

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