Imaging of the foot and ankle

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Abstract
There are a number of imaging modalities available to assist in assessment of the foot and ankle. The variety of techniques will be described with emphasis on the particular advantages and limitations of each. Recent advances and variations relating to the individual modalities are reviewed together with specific clinical scenarios.

Keywords ankle; diagnostic imaging; foot

Introduction
Imaging of the foot and ankle is commonly undertaken and there is a wide range of modalities available for assessment of a variety of abnormalities. Radiography remains the mainstay of imaging but there are several more advanced techniques which can be usefully applied. An understanding of these is critical for a balanced approach to imaging.

Plain radiographs
The initial evaluation of many musculoskeletal conditions of the foot and ankle is with plain radiographs. These are produced through variations in the absorption of ionizing radiation by the body’s tissues, resulting in excellent spatial resolution between soft tissue and bone due to their differing attenuation values.

Typically two views of a body part are taken, conventionally in the anteroposterior (AP) and lateral planes. Due to the complex anatomy within the ankle and foot this is frequently modified depending on clinical concern. The use of weight-bearing films, other than in trauma, allows for standardization of images and can reveal subtle but important changes in alignment (Figure 1).

A modified AP image with the foot and ankle in 15–20° of internal rotation, the mortise view, provides unobstructed assessment of the talus dome (Figure 1a), as a standard AP image can obscure pathology here. In the foot, due to the overlapping orientation of the tarsal arches, oblique images can provide valuable supplementary views but do not replace the standard radiological assessment.

Advantages
Radiographs are widely available and relatively inexpensive. For the diagnosis of bony abnormalities plain radiographs are particularly useful. The demonstration of a joint effusion or soft tissue swelling is useful in cases of radiographically occult injuries (Figure 2).1

Disadvantages
The acquisition of plain radiographs involves ionizing radiation and whilst the dose to the extremity is minimal, the potential hazards of radiation should not be ignored. Whilst allowing a limited soft tissue evaluation as alluded to above, a detailed review of the soft tissues is not possible on radiographs due to the narrow range of attenuation values between them. It is important that additional imaging is performed if clinical concern persists.

Variations
Stress views: active or passive stress views may demonstrate indirect evidence of a ligamentous injury. The combination of the additional applied force and an underlying ligamentous disruption results in widening of the joint space. In the ankle, stress views can evaluate disruption of the lateral ligament complex (talar tilt), the medial ligament complex and the tibiofibular syndesmosis.

Fluoroscopy: fluoroscopic techniques are typically used in orthopaedic surgery and radiological services to guide fracture reduction or aid interventional procedures. Similar to standard radiography this modality utilizes a X-ray source but produces real time dynamic images and allows dynamic evaluation of the joint.

Arthrography: arthrography involves the injection of a radiopaque contrast agent into a joint, typically under fluoroscopic guidance, or alternatively with ultrasound. Indirect information pertaining to the soft tissues can be deduced from the pattern of distribution of the injected contrast medium. Both diagnostic and therapeutic joint injections are frequently combined with arthrographic procedures via injection of local anaesthetic or steroid agents respectively.

In the foot and ankle, arthrography is typically performed in conjunction with MRI or less frequently CT utilizing a suitable contrast agent.

Tomosynthesis: the conventional radiographic technique can be modified to acquire numerous low dose images of specific body part at differing focal depths. Digital tomosynthesis is established in breast imaging and in the evaluation of pulmonary nodules but has expanded into musculoskeletal imaging. The radiation dose is greater than conventional radiography but is less than CT and this modality shows promise in the evaluation of post-operative patients with potential reduction in the extent of streak artefact. Studies have demonstrated the value of tomosynthesis in relation to wrist fractures but there is potential to investigate for occult bone injury in any area where complex anatomy or soft tissue overlay limits evaluation or where abnormalities are radiographically occult (Figure 3).3

Ultrasound (US)
US plays a key role in the diagnosis and management of musculoskeletal disease. For the evaluation of superficial musculoskeletal structures a high frequency probe is necessary, typically a linear array probe of at least 7 MHz and ideally 10 MHz or greater. This enables greater spatial resolution at the expense of limited depth penetration. A small footprint probe if
available can be a usual adjunct particularly in the foot. Whilst evaluation of the bone is not possible with US the periosteum is well visualized and occult stress fractures of the ankle or metatarsals can be detected. 4

Advantages
When compared to other imaging modalities, US offers the unique advantage of dynamic assessment. It is a high resolution, rapid real time examination which can be focused on the exact site of clinical symptoms and involves no radiation. Tendons and ligaments can be evaluated during active or passive movement. For example, dynamic US can elucidate peroneal subluxation not evident on static imaging.

Figure 1 Diabetic patient with distal neuropathy. (a) Weight-bearing mortise radiograph demonstrates talar tilt not appreciated on (b) reformatted coronal CT of the same patient.

Figure 2 Lateral radiograph demonstrates an ankle joint effusion (arrowheads) but no fracture following trauma.

Figure 3 Digital tomosynthesis ankle mortise radiograph shows a minimally displaced lateral malleolus fracture (arrow) not evident on standard radiography.
Doppler evaluation for vascularity is a valuable tool used in the imaging of joints for active inflammation, tendons for neovascularity and assessment of blood flow within soft tissue lesions (Figure 4). Both colour and power Doppler techniques can be used but the latter is preferred in the foot and ankle as it is more sensitive to blood flow. Information on the direction of flow provided by colour Doppler is less important in musculoskeletal US. Due to the superficial location of the ankle and foot tendons, US is an ideal modality to evaluate these structures.

Ultrasound is widely used for image guided musculoskeletal procedures, and allows excellent needle visualization.

Disadvantages

The main limitation of US is its operator dependence. In addition, musculoskeletal US has a number of specific artefacts that can influence image quality, the most frequently encountered is anisotropy. When the US beam is perpendicular to a tendon, the normal tendon has a characteristic hyperechoic, fibrillar appearance. If the beam is at an oblique angle, the tendon becomes more hypoechoic, with this artefact known as anisotropy. This is an important pitfall in the imaging of tendons, ligaments and muscle, as pathology can also cause these structures to appear hypoechoic. A combination of manual angulation and electronic tilting of the beam can reduce anisotropic artefact.

Variations

Extended field of view imaging (EFOV): panoramic scanning or extended field of view imaging can be used to demonstrate an abnormality that is greater than the width of the ultrasound probe. While the diagnostic quality of the ultrasound is not improved, this technique produces a continuous image, which can be a useful overview of the relevant finding for the referring clinician (Figure 5).

US elastography: traditional US, termed B-mode, relies on morphological changes to indicate an underlying pathological process. The addition of elastography provides a measure of tissue stiffness by gentle manual compression. In foot and ankle imaging this has potential for detection of tissue softening occurring for example as part of Achilles tendinopathy (Figure 6). Elastography is well established in other radiological sub-specialties such as breast imaging and research is ongoing to quantify the benefit of sonoelastography over conventional techniques for musculoskeletal diseases.

Contrast enhanced US (CEUS): microbubble contrast agents, administered intravenously, can be detected with standard US equipment. The microbubbles are extremely echogenic and can be used to evaluate microcirculation. The technique has not yet moved into the clinical arena for musculoskeletal assessment but CEUS is emerging as a promising adjunct in the research forum particularly in rheumatological conditions where neovascularity is an important early finding in many disease processes.

Computed tomography (CT)

Technique

Multiple parallel images are produced through an array of X-ray detectors that move circumferentially around a patient, while the patient is moved through a CT scanner. The spatial resolution of CT renders it an ideal modality to evaluate bone and soft tissue calcification. Whilst acquired axially, images can subsequently be reconstructed in multiple planes, typically coronal and sagittal. For surgical planning a 3-D surface rendered image can be produced from the 2-D data (Figure 7).

For musculoskeletal extremity imaging, depending on the clinical scenario iodinated contrast can be administered to evaluate peripheral vascularity for example in trauma with suspected vascular compromise or to further evaluate a soft tissue mass.

Advantages

The process of acquiring a CT takes seconds and is well tolerated by most patients. In the preoperative planning of fractures, in particular of complex intra-articular fractures, cross-sectional imaging with CT offers a detailed evaluation of fracture complexity and greater detection of loose bodies than plain radiographs.

Disadvantages

Similar to conventional radiography, CT involves ionizing radiation but at a higher dose. The predominant limitation of CT
is in its poor evaluation of soft tissue structures as when injured they cannot easily be delineated from the adjacent normal soft tissues. Whilst more problematic with MRI, metallic artefact from a surgical prosthesis can obscure detail on CT.

**Advances**

**Dual energy CT:** in dual energy CT two X-ray tubes at different kilovoltages simultaneously acquire data sets of the desired region. A comparison between attenuation values at these two acquisitions allows differentiation between uric acid and calcium, and hence can be used to image for uric acid crystals in tophaceous gout. Dual energy CT also has potential in the evaluation of traumatic bony injuries and detecting acute marrow oedema. Dose reduction techniques both in standard and dual energy CT are being utilized without compromising the diagnostic ability of the study.

**Magnetic resonance imaging (MRI)**

**Technical factors**

MRI has revolutionized musculoskeletal imaging, and offers excellent spatial and contrast resolution. An MR image is produced by the effect of a strong homogeneous magnetic field on the body’s hydrogen nuclei in water molecules, hence avoiding ionizing radiation and the potential associated risks.

Part of the complexity of MRI is centred on the vast variety of sequences available, with inconsistency in terminology between different manufactures. For general musculoskeletal imaging, MR sequences can be simplified into three main groups. T1 weighted sequences show fat as bright or high signal and fluid as dark or low signal. They are particularly useful for anatomical assessment. T2 weighted sequences are fluid sensitive and show fluid or oedema as high signal. Fat is also bright on T2 weighted images and so to increase the conspicuity of fluid, the signal from fat can be suppressed (T2fs). A frequently used alternative to fat saturation is the short tau inversion recovery (STIR) sequence. Proton density (PD) sequences have been optimized for hyaline cartilage assessment; they are also fluid sensitive and like T2 weighted sequences, are often combined with fat suppression (PDfs).

**Advantages**

MRI provides excellent spatial and contrast resolution of the ankle and foot without reliance on ionizing radiation. MRI is widely utilized in the evaluation of tendon and ligament pathology as well as providing detailed review of bone and joint abnormalities (Figure 8).

**Disadvantages**

Due to the strong magnetic field many implantable devices such as pacemakers are not MR compatible. The development of wide, short bore MRI scanners has increased compliance in claustrophobic patients. Each sequence of a diagnostic study requires the patient to remain completely still, with a much longer scanning time compared to CT. Unlike CT the majority of sequences in common usage must be acquired in the plane they are to be viewed in and it is not possible to manipulate the images to reformat in an alternative plane.
Susceptibility artefact from ferrous material impacts on image quality due to image distortion and signal voids. The newer generation orthopaedic titanium and non-ferrous prostheses are less problematic; however imaging of the older generation prostheses is a challenge with development of metal artefact reduction sequences (MARS) to minimize artefactual distortion. While MRI is highly sensitive, it is not always specific and study findings need to be interpreted in the context of the clinical scenario and the appearance on other imaging modalities. For example an MRI examination will detect increased fluid or oedema, but cannot always differentiate between various aetiologies including trauma, infection or malignancy.

**Advances**

**MR arthrography:** MR arthrography can be performed as a conventional injection of contrast into the joint (direct arthrography) which has the benefit of joint distension but also has potential risks such as infection. Alternatively, indirect arthrography can be performed by intravenous injection of contrast medium with delayed imaging of the joint although the lack of distension can be problematic. In the ankle joint both direct and indirect techniques can have a role in the evaluation of a range of pathologies including ligamentous injuries, impingement syndromes, cartilage lesions, loose bodies, osteochondral lesions of the talus, and synovial joint disorders but with MRI advances including the use of 3 T scanners, many units no longer use arthrography routinely.

**Cartilage imaging:** MRI provides an excellent non-invasive evaluation of articular cartilage. As the treatment of chondral injury evolves there has been increased focus on the development of accurate cartilage specific sequences which focus both on the biochemical alterations and on the morphological changes including fissuring, thinning and cartilage loss. Alterations in the water or sodium content of cartilage or in the proteoglycan composition and distribution can predict cartilage damage. Evaluation with T2 mapping or sequences such as delayed gadolinium-enhanced MR imaging cartilage (dGEMRIC) can identify an irregularity of chondral make-up which precedes any morphological abnormality.

**Nuclear medicine**

A standard bone scintigram is the most common nuclear medicine technique used for the evaluation of musculoskeletal disorders and in the foot is particularly useful in the evaluation of stress fractures of the metatarsals. A radioactive substance, typically technetium-99m labelled methylene disphosphonate ($^{99m}$TcMDP) is injected into the patient. As this undergoes radioactive decay it emits gamma rays which are detected by a gamma camera. Three phase imaging to include an arterial phase, blood pool phase and bone scan image can be performed to improve differentiation between bone and soft tissue. The

**Figure 8** Sagittal PDfs MR demonstrates abnormal bone marrow signal in the talar dome with a classical geographic distribution in avascular necrosis (arrow) due to systemic steroids. Normal marrow in the adjacent calcaneum and tibia.

**Figure 9** Bone scintigram shows increased joint based radiotracer uptake in right foot Charcot.

**Figure 10** SPECT. Fused scintigram and low resolution CT shows increased radiotracer uptake in a 2nd metatarsal stress fracture.
tracer detects increased osteoblastic activity and hence areas of increased bone turnover (Figure 9).

**Advantages**
Bone scintigraphy is widely available, is highly sensitive for a range of osseous conditions and is generally well tolerated by patients.

**Disadvantages**
While bone scintigraphy is highly sensitive, it has a low specificity. A variety of bone disorders including trauma, degeneration, malignancy and infection can cause increased tracer uptake. Processes without increased osteoblastic activity such as multiple myeloma or lytic metastases may be occult. Lack of anatomical differentiation can limit detail in complex anatomical areas. The radiation dose is greater than standard radiography.

**Variations**
Multi-planar data can be acquired using single photon emission computed tomography (SPECT) utilizing similar radiopharmaceuticals to traditional scintigraphy. Multi-planar SPECT-CT combines both SPECT and CT imaging resulting in greater anatomical evaluation of many musculoskeletal conditions (Figure 10).11

**Specific clinical scenarios**

**Fractures**

**Stress and occult fractures:** whilst the majority of fractures will be diagnosed with plain radiographs, MRI, CT and scintigraphy all play an important role in the diagnosis of stress fractures and in the detection of clinically suspected but radiographically occult fractures in the setting of trauma. In the ankle and foot stress fractures are common, frequently involving the second metatarsal, calcaneus and less commonly the talus or navicular. A fracture line on MR is depicted as a very low signal intensity line with associated changes within the adjacent bone consistent with oedema and haemorrhage (Figure 11). A bone bruise is radiographically occult but at MRI is depicted as an ill-defined area of low signal on T1 and high signal on T2 or STIR, which is confined to the medullary cavity. Stress fractures in nuclear medicine studies are revealed as focal areas of increased radiotracer uptake (Figure 10).

**Osteochondral fractures:** in the ankle an osteochondral fracture typically involves the talar dome most commonly occurring in radiographs of the mid and forefoot demonstrates a Lisfranc fracture at the base of the 2nd metatarsal with normal alignment.
the middle third of the lateral border and in the posterior third of the medial border. An osteochondral fragment partially or completely detaches as a result of single or multiple traumatic insults. The staging of these lesions is based on the condition of the subchondral bone and the integrity of the articular cartilage. Both plain radiographs and CT can detect these lesions, however MRI provides important information regarding condition of the articular cartilage, the viability and stability of the bone fragment and the extent of any healing.

**Lisfranc injury:** conventional radiographs can indicate a fracture or malalignment in the case of Lisfranc injury but changes can be subtle and may be missed (Figure 12). It is possible to optimize radiographs but in the majority of cases additional imaging with CT or MRI is required.

**Tendon disease**
The posterior, medial and lateral tendons of the ankle and foot are particularly prone to acute and chronic injury. Acute tenosynovitis manifests as increased fluid in the tendon sheath with a normal appearance of the tendon. In chronic tenosynovitis the tendon may appear nodular or diffusely thickened. Tendinosis depending on its severity will cause mild to severe thickening and heterogeneity to the tendon and can make assessment for a partial tear more difficult.

**Achilles tendon:** both MRI and ultrasound are widely used in the evaluation of Achilles tendon pathology and both imaging modalities can readily detect all aspects of tendon disease (Figures 6a and 13). In the acute setting the dynamic nature of ultrasound gives it an advantage over MRI in the assessment of Achilles tears as it is possible to calculate separation of the tear in plantar flexion and thus guide treatment. The greater resolution of US also allows confident assessment of alternative causes of calf pain, in particular plantaris injury.

Insertional Achilles tendinosis may be associated with a Haglund deformity, retrocalcaneal or Achilles bursitis, focal thickening of the tendon at its insertion, readily diagnosed with ultrasound and MRI. Intrasubstance calcification is more readily assessed using US and/or plain film. At MRI, calcaneal marrow oedema and increased signal within the distal tendon may be demonstrated (Figure 13b).

**Tibialis posterior tendon dysfunction:** chronic tendon rupture typically occurs at the level of the medial malleolus affecting women in the 5th and 6th decades who develop a progressive flat foot deformity. In contrast, in younger athletic patients tears either partial or complete occur at the navicular insertion. Acute tenosynovitis is also seen in the young athletic patient secondary to overuse. Tibialis posterior abnormalities can be appreciated using US or MRI (Figure 14).
**Peroneal tendons:** in the younger athletic population peroneal tears are typically secondary to overuse, with the older population developing degenerative tears. Peroneus brevis has a distinctive appearance at MRI in the presence of a longitudinal intrasubstance tear, which classically originates in the fibular groove and demonstrates an inverted v shape, enveloping the peroneus longus tendon (Figure 15). On axial MRI images, dislocation is readily diagnosed with the peroneal tendons located anterior and lateral to the distal fibula. The dynamic nature of ultrasound is of particular use in evaluating for intermittent or internal peroneal tendon subluxation where it is superior to a static MRI study.

**Flexor hallucis longus tendon:** this tendon is vulnerable to injury as it passes through the fibro-osseous tunnel bounded by the lateral and medial talar tubercles, where the tendon may develop chronic or stenosing tenosynovitis, tendinosis, partial or complete tear secondary to chronic repetitive friction. Imaging features of tenosynovitis and tendinosis can also occur distally at the knot of Henry.

**Ligaments**

**Medial and lateral ligament injuries:** the normal peri-ankle ligaments should be well defined low signal linear structures. In the acute setting lateral collateral ligament and medial collateral ligament injuries are well demonstrated on MRI. Given that acute ankle ligamentous injuries are rarely treated surgically, US and MRI tend to be reserved for high level athletes where surgical repair may be undertaken and in the evaluation of chronic ankle instability. The lateral ligament complex injuries follow a predictable pattern of injury with the anterior talofibular ligament tearing first followed by the calcaneofibular ligament and finally the posterior talofibular ligament. Acute rupture on MRI is diagnosed by morphological and signal intensity alterations including discontinuity, detachment, thinning, thickening or irregularity of the ligament (Figure 16). Co-existent bony oedema, soft tissue oedema and extravasation of joint fluid may be present. In a chronic tear the ligament affected may appear thinned, thickened, irregular in contour, wavy, or elongated with adjacent scarring or synovial proliferation.

Contusional injuries in particular of the tibiotalar component of the deltoid ligament complex have a high association with inversion sprains. These contusions result in loss of the normal striations within the deltoid, with the ligament demonstrating homogenous intermediate signal intensity.

**Figure 15** Axial PDfs MRI demonstrates a longitudinal split within the peroneus brevis tendon which appears as an inverted V (arrow).

**Figure 16** Axial PDfs MRI demonstrates a complete anterior talofibular ligament rupture with proximal and distal ligament stumps (arrowheads).

**Figure 17** Sonogram of plantar fasciitis with thickening of its calcaneal origin (callipers).
Compressive neuropathies

The two most common compressive neuropathies in the foot and ankle are Morton’s neuroma and tarsal tunnel syndrome, with less frequently encountered neuropathies such as sural nerve entrapment syndrome, and deep and superficial peroneal nerve entrapment syndromes.

Morton neuroma: a Morton neuroma or interdigital neuroma is a benign fibrosing process of an intermetatarsal nerve, with resultant perineural thickening. These are often associated with an intermetatarsal bursa and the diagnosis can be confirmed with either MRI or ultrasound. On MRI a Morton neuroma is a dumbbell shaped mass demonstrating low to intermediate signal on T1 and T2 weighted imaging, often more conspicuous on T1 imaging due to the surrounding hyperintense fat. It may be associated with an intermetatarsal bursa which presents as a fluid signal mass. Ultrasound offers dynamic evaluation of the hypoechoic mass with compression of the metatarsal heads to cause plantar displacement of the mass and a palpable click (the sonographic Mulder sign). At ultrasound the frequently associated intermetatarsal bursa presents as an anechoic fluid collection.4

Tarsal tunnel syndrome: nerve compression or entrapment can occur at any level of the posterior tibial nerve or its branches (medial plantar nerve, lateral plantar nerve, medial calcaneal nerve) with the resultant clinical symptoms varying according to the level of compression.26 MRI can evaluate mass lesions compressing these nerves within the tarsal tunnel including ganglions, varicosities, accessory muscles, lipomas, neurogenic tumours, scar tissue and synovial hypertrophy.15 MRI can also demonstrate secondary signs of nerve compression such as atrophy of abductor digiti quinti in Baxter’s neuropathy. Entrapment of the medial plantar nerve in the narrow space between

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**Figure 18** (a) Oblique radiograph shows fibrous calcaneonavicular coalition with the anteater nose sign of the anterior process of the calcaneum. (b) Lateral radiograph shows talar beaking (arrow) and the continuous C-sign (arrowheads) in talocalcaneal coalition. (c) Sagittal T2fs demonstrates fibrous calcaneonavicular coalition with bone marrow oedema (arrow). Talar dome osteochondritis (arrowhead).

**Figure 19** (a) DP radiograph shows cortical destruction of the hallux distal phalanx in osteomyelitis (white arrow). (b) Short axis T1fs post gadolinium MRI of a different patient shows 2nd metatarsal osteomyelitis (arrow) and a plantar soft tissue abscess (arrowheads) contiguous with an ulcer (not shown).
the abductor hallucis muscle and the knot of Henry results in jogger’s foot with this complex anatomy well evaluated with MRI.²⁷

**Plantar fascia**

The plantar fascia is readily evaluated with both ultrasound and MRI. At MRI the normal fibrous fascia is a thin band measuring 2–4 mm with low signal intensity on all sequences.²⁸ On ultrasound the plantar aponeurosis is a uniform, fibrillar structure, measuring 4 mm or less at its calcaneal origin.⁴

Plantar fasciitis from repetitive microtrauma or in association with an enthesopathy has characteristic MR findings of thickening and oedema of typically the proximal aspect of the medial plantar fascia.⁴ Oedema may be present within the adjacent calcaneum and heel fat pad. At US, plantar fasciitis manifests as hypoechoic thickening (>4 mm) of the calcaneal origin (Figure 17).² US can guide steroid injection and dry needling as part of management.

The fibrous proliferation of plantar fibromatosis can be demonstrated as single or multiple fusiform nodules within the plantar fascia which are hypoechoic or isoechoic on ultrasound and low to intermediate signal intensity on T1 and T2 weighted MRI. If larger the nodules may be heterogenous on MRI and may be locally aggressive involving the plantar musculature.²⁹

**Coalition**

Tarsal coalitions can be radiologically assessed with plain film, CT and MRI. Even when there is a complete bony synostosis, the radiographic features can be subtle but classic findings are described in the more common types of coalition (Figure 18a and b). Fibrous and cartilaginous coalition causes cortical irregularity and is often associated with osseous oedema (Figure 18c).

**Infection**

Whilst established bone destruction can be detected on serial plain radiographs (Figure 19a), MRI is frequently used in the evaluation of osteomyelitis to differentiate soft tissue infection from osteomyelitis and to establish the extent of involvement (Figure 19b). Small locules of gas can be difficult to appreciate on MRI but are evident both on plain film and CT.

**The neuropathic foot**

The chronic stage of neuroarthropathy, the Charcot joint, is well recognized on plain film (Figure 20). The earlier stages are often radiographically occult but MRI and scintigraphy can identify neuropathy before deformity occurs and help differentiate it from infection. In diabetes and other causes of neuropathy, infection is almost always contiguous with a soft tissue ulcer.³⁰ This and the secondary signs of infection such as an abscess can help to differentiate from abnormalities due to neuropathy where bone marrow changes in MRI and increased radiotracer uptake in scintigraphy tend to be periarticular and subchondral (Figure 9).

**Conclusion**

The foot and ankle are commonly imaged for a wide range of abnormalities. An understanding of the array of techniques available including their strengths and weaknesses allows a rational approach to imaging.


