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Ankle and/or Hindfoot Pain AUC

2022 Update

Appropriateness of advanced imaging procedures* in patients with ankle and/or hindfoot** pain:

09/27/2022

*Including MRI, MR arthrography, CT, CT arthrography, Nuclear medicine w/ or w/o SPECT, or PET
**Hindfoot refers to structures posterior to the tarsometatarsal joints

Abbreviation list:

ACOEM	American College of Occupational & Environmental Medicine	LAS	Lateral ankle sprain
		MRA	Magnetic resonance arthrography
AAOS	American Academy of Orthopaedic Surgeons	MRI	Magnetic resonance imaging
		NICE	National Institute for Health and Care Excellence
ACR	American College of Radiology		
AVN	Avascular necrosis	OA	Osteoarthritis
AUC	Appropriate Use Criteria	OAR	Ottawa ankle rules
CT	Computed tomography	OCD	Osteochondral defect
CTA	Computed tomographic arthrography	ON	Osteonecrosis
		PET	Positron emission tomography
DM	Diabetes mellitus	PLE	Provider Led Entity
EULAR	European League Against Rheumatism	SPECT	Single-photon emission computerized tomography
In-111 WBC	Indium 111-labeled white blood cell	SVS	Society for Vascular Surgery
		TC-99m	Technetium-99m
IWGDF	International Working Group on the Diabetic Foot	TTS	Tarsal tunnel syndrome
		US	Ultrasound

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Appropriate Use Criteria: How to Use this Document

The CDI Quality Institute follows the recommendation framework defined by the Appraisal of Guidelines for Research & Evaluation (AGREE II), AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews) and a modified version of the QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies) to evaluate the strength of recommendations concerning advanced imaging. Considerations used to determine a recommendation are listed below.

Primary recommendation (green): A strong recommendation for initial imaging for this presentation; there is confidence that the desirable effects of imaging outweigh its undesirable effects.

Alternative recommendation (yellow): A conditional recommendation for imaging; the desirable effects of imaging likely outweigh its undesirable effects, although some uncertainty may exist. The individual patient's circumstances, preferences, and values should be considered on a case-by-case basis. This may include: contraindication to the primary recommendation, specific clinical circumstances that require use of the alternative recommendation, or the primary recommendation has results that are inconclusive or incongruent with the patient's clinical diagnosis.

Recommendation against imaging (red): The undesirable effects of imaging outweigh any desirable effects. Additionally, the recommendation may be impractical or not feasible in the targeted population and/or practice setting(s).

Ankle and/or hindfoot AUC Summary:

- **Conventional radiographs** are used for the initial evaluation in most cases of ankle and/or hindfoot pain, including suspected injury or fracture, osteoarthritis, or other chronic or unexplained pain.
- In most instances, **MRI (without IV contrast)** is the initial advanced imaging procedure of choice for ankle and/or hindfoot pain. It is indicated for suspected structural derangement following acute injury, severe or atypical osteoarthritis, and suspected occult or stress fractures not identified on initial radiographs.
- **CT (without IV contrast)** can be useful for initial advanced imaging of acute injury, when pre-surgical planning is requested, or when foreign body is suspected. It may also be the modality of choice in select scenarios when MRI is not available or previous MRI findings are non-diagnostic.
- **Bone scan** can be useful for patients with suspected stress or occult fracture, osteonecrosis, or osteomyelitis for evaluating recent findings on noncontrast MRI or when MRI is not available. The addition of **SPECT or SPECT/CT**, when available, may increase the specificity of a bone scan.
- **CT arthrography** or **MR arthrography** can be helpful to assess for instability, cartilage abnormality, intra-articular bodies, or impingement in cases of chronic pain and/or suspected osteochondral defect.
- **Ultrasound**, while not defined as an advanced imaging modality, can be useful in the initial assessment of the Achilles tendon, plantar fascia, and tarsal tunnel syndrome. It is also the modality of choice for radiolucent foreign bodies.

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Acute ankle and/or hindfoot injury with suspected structural derangement, no fracture or alignment abnormality on radiographs, and either of the following:

- **Significant pain with disability or deformity**
- **Pre-surgical planning**

- **Yellow – MRI without IV contrast**
- **Yellow – CT without IV contrast**
- **Red – MRI without and with IV contrast**, **CT with IV contrast**, **CT without and with IV contrast**, **bone scan**, **SPECT**, **PET**, **MR arthrography**, **CT arthrography**

Level of Evidence: MRI without contrast: moderate; CT without contrast: low; bone scan; MRI without and with contrast, MR arthrography, CT arthrography, CT with contrast, CT without and with contrast, PET/CT: insufficient

Notes concerning applicability and/or patient preferences:
None

Guideline and PLE expert panel consensus opinion summary:
An acute injury is defined as a discrete event resulting in excessive force on the ankle/hindfoot, in contradistinction to overuse injuries that result from chronic repetitive injuries or insufficiency injuries resulting from normal forces on structurally deficient bone (PLE expert panel consensus opinion). Generally, the acute timeframe spans from immediate time of injury to < 3 weeks (Smith et al [*ACR*] 2020). Structural derangement may be suspected after an acute injury when signs and symptoms such as instability, locking, catching, effusion, inability to bear weight, bone tenderness, loss of motion, and/or pathological laxity are present (PLE expert panel consensus opinion). However, in many cases, advanced imaging is usually not needed until after a period of conservative care and observation, as many problems improve quickly once any red flags (fracture, dislocation, neurovascular compromise, tendon rupture, or neoplastic, metabolic, inflammatory or infection disorders) are ruled out (Hegmann et al [*ACOEM*] 2018).

Ottawa Rules and Conventional Radiography
The current standard for determining if radiographs are necessary for ankle injuries is the *Ottawa Ankle Rules* (*OAR*), which have been validated in those > 5 years of age (Smith et al [*ACR*] 2020). The OAR generally apply during the first 1- to 3-week interval following initial injury, and recommend ankle radiographs in those with any of the following: 1) inability to bear weight; 2) point tenderness over the medial malleolus, posterior edge or inferior tip of lateral malleolus, talus, or calcaneus; or 3) inability to ambulate for four steps (Smith et al [*ACR*] 2020). The OAR should not be used in those with neurologic abnormality or decreased sensation (Smith et al [*ACR*] 2020). Radiographs are indicated for initial imaging in those meeting OAR criteria, with a demonstrated sensitivity of 92%-99% (Smith et al [*ACR*] 2020). MRI, CT, bone scan, and ultrasound are not routinely used as the first imaging study for evaluating acute trauma to the ankle with positive OAR (Smith et al [*ACR*] 2020).

Like the OAR, Ottawa rules for the foot have also been developed, and state that a series of foot radiographs is required for foot pain only if there is point bone tenderness of the navicular [or base of fifth metatarsal – out of scope for this guideline] or an inability to bear weight or walk four steps

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(Gorbachova et al [*ACR*] 2019). Studies have shown that these foot rules have a sensitivity of 99% and a median specificity of 26% (Gorbachova et al [*ACR*] 2019). Like the OAR, the Ottawa foot rules have a variety of exclusions, such as neurologic abnormality or > 10 days after trauma (Gorbachova et al [*ACR*] 2019). Radiographs are indicated by positive Ottawa foot rules and are the mainstay of initial imaging in the setting of acute foot trauma (Gorbachova et al [*ACR*] 2019).

MRI

For acute ankle and foot injuries with positive findings on the OAR, MRI without IV contrast can be appropriate in the presence of significant pain and disability and negative radiographs (Bussieres et al 2007; Smith et al [*ACR*] 2020). MRI of the ankle without IV contrast is sensitive for soft-tissue injuries and is also the reference standard for ligamentous injury and assessment of stability, allowing distinction between tendinopathy, sprain, and partial or complete tears (Smith et al [*ACR*] 2020). MRI has demonstrated sensitivity for diagnosing acute tendon rupture or foot dislocation (Gorbachova et al [*ACR*] 2019) and may also be useful to diagnose underlying joint damage (Vuurberg et al 2018). In case of suspicion of high-grade ligament injuries or syndesmotic injuries and occult fractures, an MRI can be performed because of its excellent sensitivity and specificity for visualizing these injuries (Vuurberg et al. 2018). MRI can also be useful when there is uncertainty of tendon injury or if concomitant osseous injury is suspected (Gorbachova et al [*ACR*] 2019). It should be noted that some guidelines are unable to recommend for or against MRI in certain scenarios such as acute ankle sprain (e.g., Hegmann et al [*ACOEM*] 2018; strength of evidence: insufficient, level of confidence: low). The American Association of Orthopedic Surgeons does not recommend for or against MRI in diagnosing Achilles tendon rupture (Chiodo et al [*AAOS*] 2010; strength of recommendation: inconclusive), with others recommending its use for this scenario (Hegmann et al [*ACOEM*] 2018; strength of evidence: recommended, insufficient evidence (I), level of confidence: moderate; Smith et al [*ACR*] 2020).

CT

When there is acute ankle or foot injury with positive findings on the OAR, CT (without IV contrast) may also be an appropriate imaging modality in the presence of significant pain and disability and negative radiographs (Bussieres et al 2007; Smith et al [*ACR*] 2020). While MRI is the preferred modality for soft-tissue evaluation, CT can also be useful, particularly when dislocation or syndesmotic injury are suspected (Smith et al [*ACR*] 2020). While some guidelines do not recommend for or against the use of advanced imaging in assessing injuries such as acute ankle sprain (e.g., Hegmann et al [*ACOEM*] 2018; strength of evidence: insufficient, level of confidence: low), others note that CT can be effective for documenting various tendon entrapment and dislocations, particularly peroneal dislocations and peroneal retinacular injuries (Gorbachova et al [*ACR*] 2019). The use of CT with IV contrast is not indicated for this scenario (Smith et al [*ACR*] 2020).

Clinical notes:

- In the common scenario of severe ankle sprain, a fracture should be excluded by proper use of the OAR, and if indicated, conventional radiographic imaging should be undertaken (Vuurberg et al 2018). Studies have shown that less than 2% of those negative for fracture using the OAR actually have a fracture (Smith et al [*ACR*] 2020).
- Ultrasound is not recommended for initial evaluation of patients with acute ankle sprain, as findings in the acute setting are unlikely to alter management (Hegmann et al [*ACOEM*] 2018). It may be useful as a secondary evaluation modality for focused evaluation of underlying soft-tissue injuries and ligaments (Smith et al [*ACR*] 2020).
- Ultrasound is recommended as the main confirmatory diagnostic test for Achilles rupture, particularly when there is diagnostic uncertainty (Hegmann et al [*ACOEM*] 2018).

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- Bone scan is not typically used in this clinical scenario (Smith et al [*ACR*] 2020).
- Arthrography is not recommended as a diagnostic tool for ankle sprains in the acute setting (Vuurberg et al 2018).

<u>Evidence update (2015 – Present):</u>

Moderate Level of Evidence

Krahenbuhl et al (2018) conducted a systematic literature review of current diagnostic imaging options for assessing distal tibio-fibular syndesmosis. Forty-two articles were included and subdivided into three groups: conventional radiographs (22 articles), CT (15 articles), and MRI (9 articles). Overall, the included studies showed low probability of bias and were deemed applicable in daily practice. Results found that conventional radiographs cannot predict syndesmotic injuries reliably, and CT scans outperform plain radiographs in detecting syndesmotic malreduction. Additionally, the syndesmotic interval can be assessed in greater detail by CT. MRI measurements achieve a sensitivity and specificity of nearly 100%; however, correlating MRI findings with patients' complaints is difficult, and utility with subtle syndesmotic instability needs further investigation.

Low Level of Evidence

Barini et al (2021) conducted a systematic review and meta-analysis to analyze the diagnostic accuracy of MRI on acute anterior talofibular ligament (ATFL) injury. Quality of retrieved studies was assessed using the QUADAS-2 tool, and data were extracted to calculate pooled sensitivity and specificity of MRI. A total of seven studies met inclusion/exclusion criteria. For MRI, pooled sensitivities and specificities in diagnosing acute ATFL injury were 1.0 (95% CI, 0.58-1) and 0.9 (95% CI, 0.79-0.96), respectively. Pooled positive likelihood ratio was 10.4 (95% CI, 4.6-23) and pooled negative likelihood ratio was 0 (95% CI, 0-0.82). The authors conclude that MRI shows high diagnostic accuracy in the diagnosis of acute ATFL lesions.

Chun et al (2019) conducted a systematic review and meta-analysis to determine whether radiologic tests accurately and reliably diagnose ankle syndesmosis injury. A total of 8 studies were included for qualitative synthesis, and 6 used for meta-analysis. Pooled sensitivity and specificity were 0.528 and 0.984 for radiographs, 0.669 and 0.87 for CT, and 0.929 and 0.865 for MRI, respectively. Syndesmosis injuries differed significantly in the accuracy of radiological methods according to the presence of accompanied ankle fractures. In patients with fractures, simple radiography has good specificity, and CT and MRI have high sensitivity and specificity irrespective of fracture; in particular, MRI has similar accuracy to gold standard arthroscopic findings.

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Acute ankle and/or hindfoot injury with fracture or alignment abnormality on radiographs, and either of the following:

- **Further assessment of fracture and/or associated abnormalities**
- **Pre-surgical planning**

- Green – **CT without IV contrast**
- Green – **MRI without IV contrast**
- Red – **MRI without and with IV contrast**, **CT with IV contrast**, **CT without and with IV contrast**, **bone scan**, **SPECT**, **PET**, **MR arthrography**, **CT arthrography**

Level of Evidence: MRI without contrast, CT without contrast: moderate; bone scan; SPECT; MRI without and with contrast, MR arthrography, CT arthrography, CT with contrast, CT without and with contrast, PET/CT: insufficient

Notes concerning applicability and/or patient preferences:
None

Guideline and PLE expert panel consensus opinion summary:
An acute injury is defined as a discrete event resulting in excessive force on the ankle/hindfoot, in contradistinction to overuse injuries that result from chronic repetitive injuries or insufficiency injuries that result from normal forces on structurally deficient bone (PLE expert panel consensus opinion). Generally, the acute timeframe spans from immediate time of injury to < 3 weeks (Smith et al [*ACR*] 2020).

See above scenario for discussion on the Ottawa ankle rules and conventional radiographs.

CT
CT is the first-line imaging study after radiographs to determine extent, displacement, comminution, and potential classification of fractures (Smith et al [*ACR*] 2020). It is the preferred modality for evaluating bony anatomy and particularly useful to help direct preoperative planning in subtalar, calcaneal, and talar fractures or complex comminuted injuries (Smith et al [*ACR*] 2020; Hegmann et al [*ACOEM*] 2018; strength of evidence: recommended, evidence (C), level of confidence: moderate; PLE expert panel consensus opinion). For complex ankle and foot fractures, CT can obtain greater clarity of fracture displacement, articular involvement, and subluxation of affected joints (Hegmann et al [*ACOEM*] 2018).

MRI
While CT is more commonly used for assessing known fractures, MRI is the preferred imaging modality to assess associated bone marrow contusions and soft-tissue abnormalities associated with fractures (Smith et al [*ACR*] 2020; PLE expert panel consensus opinion). Upon confirmation of a displaced, comminuted, or unstable fracture, MRI may be an important diagnostic technique for the evaluation of suspected injuries of soft tissues related to distal fibular, tibial, and malleolar fractures, such as to the syndesmotic ankle ligament complex, extensor tendons, deltoid ligament, or tibial nerve (Hegmann et al [*ACOEM*] 2018, strength of evidence: recommended, insufficient evidence / level of confidence: moderate).

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Evidence update (2015 - present):

Low Level of Evidence

Chun et al (2019) conducted a systematic review and meta-analysis to determine whether radiologic tests accurately and reliably diagnose ankle syndesmosis injury. A total of 8 studies were included for qualitative synthesis, and 6 used for meta-analysis. Pooled sensitivity and specificity were 0.528 and 0.984 for radiographs, 0.669 and 0.87 for CT, and 0.929 and 0.865 for MRI, respectively. Syndesmosis injuries differed significantly in the accuracy of radiological methods according to the presence of accompanied ankle fractures. In patients with fractures, simple radiography has good specificity, and CT and MRI have high sensitivity and specificity irrespective of fracture; in particular, MRI has similar accuracy to gold standard arthroscopic findings.

Park et al (2018) assessed the use of preoperative MRI for syndesmotic instability in 74 patients with unstable ankle fracture (Lauge-Hansen supination external rotation/Weber B type or pronation external rotation/Weber C type). MRI findings of the syndesmotic ligament and results of an intraoperative stress test were evaluated. Twenty-six patients had a positive result on the intraoperative stress test for syndesmotic instability. MRI findings of syndesmotic ligaments revealed that complete tear of the posterior inferior tibiofibular ligament (PITFL) was the most reliable predictor of syndesmotic instability (sensitivity, 74%; specificity, 78%; PPV, 54%). Interobserver agreement for intraoperative stress test and MRI assessment was excellent, except for MRI findings of the interosseous ligament (62% agreement; kappa, 0.3). The authors conclude that complete tear of the PITFL on MRI has additional diagnostic value for syndesmotic instability in ankle fracture.

Leung et al (2016) reviewed preoperative radiography and CT in 69 patients with ankle fracture to determine the value of CT for diagnosis and surgical planning. CT was deemed necessary when radiographs showed (1) comminuted fracture of the medial malleolus involving the tibial plafond, (2) comminuted fracture of the posterior malleolus, (3) presence of loose bodies, and/or (4) suspected Chaput or Volkman fracture fragment. Two orthopaedic surgeons independently reviewed the radiographs to look for CT-indicated features. Based on radiographs, 19 (28%) patients had features of posterior malleolar comminution (n=7), medial malleolar comminution (n=7), suspected Chaput fracture fragment (n=1), suspected Volkman fracture fragment (n=1), and combination of 2 lesions (n=3), and were deemed to require CT. In 10 (20%) of the remaining 50 patients, the surgical plan was modified after CT scan review. The intra- and inter-observer agreement was good to excellent. The authors conclude that radiography alone is not adequate for surgical planning for ankle fractures, and more accurate imaging tools such as CT are necessary for diagnosis.

Ohashi et al (2015) tested the diagnostic accuracy of 3D color volume-rendered (VR) CT images of the ankle for peroneal tendon dislocation in 105 patients with acute calcaneal fractures. 121 ankle CT studies from 105 consecutive patients were included. Peroneal tendon dislocation was diagnosed on multiplanar CT images by consensus of two experienced musculoskeletal radiologists and served as the reference standard. Three other musculoskeletal radiologists independently reviewed 3D images. 48 (40%) out of 121 studies showed peroneal tendon dislocation based on expert readings using multiplanar reformatted (MPR) images. Sensitivities/specificities of 3D images measured 0.92/0.81, 0.88/0.90, and 0.81/0.92 for the three readers, respectively. The area under the proper binormal ROC curve based on all three readers (0.93, 0.94, and 0.92) measured 0.93 with a 95% confidence interval of 0.89–0.98. The authors conclude that diagnostic accuracy of 3D images is comparable to, but not as good as that of MPR images for the diagnosis of peroneal tendon dislocation in patients with acute calcaneal fractures.

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Ankle and/or hindfoot pain with suspicion for stress, insufficiency, or occult fracture, and non-diagnostic radiographs:

- Green – **MRI without IV contrast**
- Yellow – **Bone scan*** [with or without **SPECT** or **SPECT/CT**]
  [previous findings on MRI without IV contrast are non-diagnostic; or patient unable to undergo MRI]
- Yellow – **CT without IV contrast**
  [previous findings on MRI without IV contrast are non-diagnostic; or patient unable to undergo MRI]
- Red – **MRI without and with IV contrast**, **MR arthrography**, **CT with IV contrast**, **CT without and with IV contrast**, **CT arthrography**, **PET**, **PET/CT**

*Bone scan is not recommended in the acute phase (up to three days in adults < 65 years of age and up to seven days in adults > 65 years of age) for diagnosis of occult fracture (PLE expert panel consensus opinion).

Level of Evidence: MRI without contrast: moderate-high; CT without contrast, bone scan with SPECT: low-moderate; MRI without and with contrast, MRI with contrast, MR arthrography, CT with contrast, CT without and with contrast, PET/CT: insufficient

Notes concerning applicability and/or patient preferences:
Nuclear medicine studies fused with CT are not yet widely available, and therefore may have applicability or generalizability issues in the community outpatient setting (PLE expert panel consensus opinion).

Guideline and PLE expert panel consensus opinion summary:

Conventional Radiography

Radiographs should be the initial imaging study for suspected stress or insufficiency fracture of the lower extremities; although not very sensitive, no further imaging is necessary if findings are conclusive for fracture (Chang et al [*ACR*] 2018; Bencardino et al [*ACR*] 2017*). Radiographs in at least two planes should initially be obtained (Bencardino et al [*ACR*] 2017). Follow-up radiographs can be used as an option for subsequent imaging (Bencardino et al [*ACR*] 2017).

MRI

MRI allows visualization of bone marrow edema patterns, which improves detection of fractures when radiographs are negative or inconclusive (Tafur et al [*ACR*] 2020). MRI without IV contrast is extremely sensitive for stress abnormalities of bone, and high field MRI with fat suppression or inversion recovery protocol is as sensitive as bone scan, making it the procedure of choice for making an early diagnosis of stress fractures (Smith et al [*ACR*] 2020; Bencardino et al [*ACR*] 2017; Bussieres et al 2007). Contrast-enhanced MRI is not considered necessary for diagnosis (Bencardino et al [*ACR*] 2017). Similarly, when occult fracture (e.g., of the talus or calcaneus) is suspected, an MRI without IV contrast can be performed because of its excellent sensitivity and specificity for visualizing these injuries (Smith et al [*ACR*] 2020; Vuurberg et al 2018; Hegmann et al [*ACOEM*] 2018; strength of evidence: recommended, insufficient evidence, level of confidence: moderate; PLE expert panel consensus opinion). This recommendation includes any scenario where radiographs appear normal with clearly abnormal clinical examination and pain/disability (Bussieres et al 2007).

Bone scan (with or without SPECT or SPECT/CT)

Previously acknowledged as the standard advanced imaging modality for stress-induced injuries, bone scan has largely been replaced by MRI (Bencardino et al [*ACR*] 2017). However, it does show stress

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fractures earlier than radiographs in many instances and can differentiate between osseous and soft tissue injury (Bencardino et al [*ACR*] 2017). In particular, bone scan can be useful for select patients with acute ankle sprain and indication of suspected stress fracture, or for helping to diagnose occult or stress calcaneus fractures (Hegmann et al [*ACOEM*] 2018; strength of evidence: recommended, insufficient, level of confidence: low to high). Bone scan with SPECT or SPECT/CT is more accurate in diagnosing stress injuries and occult fractures than planar bone scan (Bencardino et al [*ACR*] 2017; Tafur et al [*ACR*] 2020).

CT

While superior to radiography for stress fractures, CT is less sensitive than bone scan or MRI and is not typically used in the initial workup, but rather an adjunct role when other imaging modalities are equivocal (Bencardino et al [*ACR*] 2017). Talar fractures and fractures associated with the subtalar joint can be difficult to detect on radiographs but are well identified on CT (Smith et al [*ACR*] 2020; Tafur et al [*ACR*] 2020). CT may also be considered when radiographs are negative, but based on physical findings, an occult fracture is strongly suspected (Hegmann et al [*ACOEM*] 2018; strength of evidence: recommended, insufficient evidence, level of confidence: moderate) or to evaluate healing of a confirmed stress fracture (PLE expert panel consensus opinion). CT with IV contrast is not indicated in this scenario (Smith et al [*ACR*] 2020).

*This guideline did not pass the AGREE II cutoff score, but was included for its direct relevance to this clinical scenario.

<u>Clinical/Imaging notes:</u>

- Stress fractures are frequently occult on initial radiographs, with conventional radiographs having a sensitivity of 15% to 35% (Bencardino et al [*ACR*] 2017).
- Radiographs generally require 2 to 4 weeks for a stress fracture to show up (Chang et al [*ACR*] 2018; Hegmann et al [*ACOEM*] 2018).
- Short-term (10-14 days) follow-up radiographs are more sensitive than initial radiographs secondary to overt bone reaction in the location of the stress fracture (Bencardino et al [*ACR*] 2017).
- Once a diagnosis of stress fracture is made, no additional imaging is typically performed, as patients are followed clinically until they are pain free (Bencardino et al [*ACR*] 2017).
- Stress fractures are thought to be caused by repetitive loading to the bone rather than a discrete event, and history of stress fractures often includes increased physical activity or intensity of activity preceding symptoms (Hegmann et al [*ACOEM*] 2018).
- Patients at high-risk of stress fracture include athletes, middle-aged or elderly patients, and those on long-term corticosteroids (Bussieres et al 2007).
- DEXA scanning should be considered with stress fractures or insufficiency fractures in patients without a known diagnosis of osteoporosis (PLE expert panel consensus opinion).

<u>Evidence update (2014 - present):</u>

There were no new articles that significantly affected the recommendations or conclusions found in the guidelines referenced above.

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Nontraumatic ankle and/or hindfoot pain persisting after an appropriate trial (> 4-6 weeks) of conservative care, and no osteoarthritis or major abnormalities on radiographs:

- Green – **MRI without IV contrast**
- Yellow – **CT without IV contrast**
  [patient unable to undergo MRI]
- Yellow – **MR arthrography**
  [assess for instability, cartilage abnormality, intra-articular bodies, or impingement]
- Yellow – **CT arthrography**
  [assess for instability, cartilage abnormality, intra-articular bodies, or impingement]
- Yellow – **Bone scan** (with or without **SPECT** or **SPECT/CT**)
  [previous findings on MRI without IV contrast are non-diagnostic; or patient unable to undergo MRI]
- Red – **MRI without and with IV contrast**, **CT with IV contrast**, **CT without and with IV contrast**, **PET**, **PET/CT**

Level of Evidence: MRI without contrast: moderate-high; MR arthrography: moderate; CT without contrast, CT arthrography: low; SPECT/CT with bone scan: very low; MRI without and with contrast, MRI with contrast, CT with contrast, CT without and with contrast, PET/CT: insufficient

Notes concerning applicability and/or patient preferences:
Nuclear medicine studies fused with CT are not yet widely available, and therefore may have applicability or generalizability issues in the community outpatient setting (PLE expert panel consensus opinion).

Guideline and PLE expert panel consensus opinion summary:
Conventional Radiography
Conventional radiography is usually the first imaging study for chronic ankle or foot pain, as it can be useful to distinguish among the different causes and provide information about osseous and soft-tissue structures (Chang et al [*ACR*] 2018; Tafur et al [*ACR*] 2020). For most cases presenting with true foot and ankle disorders, advanced imaging studies are usually not needed until after a period of conservative care and observation, as most problems improve quickly once any red flags (fracture, dislocation, neurovascular compromise, tendon rupture, or neoplastic, metabolic, inflammatory or infection disorders) are ruled out (Hegmann et al [*ACOEM*] 2018). Other potential indications for further imaging may include persistent pain with weight bearing, a chronic feeling of instability, crepitus, catching, or locking (Hegmann et al [*ACOEM*] 2018; strength of evidence: recommended, insufficient evidence (I), level of confidence: moderate; Bussieres et al 2007).

MRI
When initial radiographs appear normal with clearly abnormal clinical examination following a period of 4-6 weeks of conservative care, MRI can be used to assess chronic ankle or hindfoot/heel pain (Chang et al [*ACR*] 2018; Hegmann et al [*ACOEM*] 2018; Bussieres et al 2007). MRI is particularly useful to evaluate for ligamentous integrity, diagnosing tendon pathology, or impingement syndrome. (Chang et al [*ACR*] 2018; Bussieres et al 2007). It can also be used to exclude other pathologic entities or plan for surgery (Chang et al [*ACR*] 2018; Bussieres et al 2007). MRI is recommended for evaluating Achilles tendinopathies and other causes of heel pain (Hegmann et al [*ACOEM*] 2018, strength of evidence:

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recommended, insufficient evidence (I) / level of confidence: moderate), and can differentiate fracture type or associated complications in the non-acute fracture patient (Hegmann et al [*ACOEM*] 2018; strength of evidence: recommended, evidence (C), level of confidence: moderate; Bussieres et al 2007). When differential diagnosis includes tarsal tunnel syndrome, plantar fasciitis, or tibialis posterior tenosynovitis, MRI is the preferred imaging modality (Bussieres et al 2007). MRI allows accurate characterization of the plantar fascia and adjacent soft-tissues and bones, but should be correlated with clinical symptoms to avoid overcalling plantar fasciitis (Tafur et al [*ACR*] 2020). In general, MR has been found to be a specific but nonsensitive method in diagnosing complex regional pain syndrome (Tafur et al [*ACR*] 2020) or entrapment syndromes, including Baxter's neuropathy (Tafur et al [*ACR*] 2020).

CT
While MRI is generally preferred, CT without IV contrast can be used in the assessment of select patients with persistent ankle or hindfoot pain following 4-6 weeks of therapy (Chang et al [*ACR*] 2018; Hegmann et al [*ACOEM*] 2018, strength of evidence: recommended, insufficient evidence (I) / level of confidence: moderate; PLE expert panel consensus opinion). This can include impingement syndromes, such as those requiring depiction of osseous causes of impingement, or when pain is believed to originate from osseous structures (Chang et al [*ACR*] 2018). CT without IV contrast can confirm the presence of an accessory ossicle, os fragmentation or fracture, or intra-articular bodies (Tafur et al [*ACR*] 2020), or investigate for bony abnormalities in cases of tarsal tunnel syndrome (Bussieres et al 2007).

CT is not routinely use for evaluation of ligamentous integrity or suspected tendon abnormality, including Achilles tendinopathy (Chang et al [*ACR*] 2018; Hegmann et al [*ACOEM*] 2018, strength of evidence: not recommended, insufficient evidence (I) / level of confidence: moderate). There is no relevant literature to support the use of CT in the evaluation of suspected complex regional pain syndrome, pathology of the plantar fascia, or the diagnosis of entrapment syndromes (Tafur et al [*ACR*] 2020).

MR or CT Arthrography
Arthrography is not routinely use for evaluation of chronic ankle sprain or suspected tendon abnormality (Chang et al [*ACR*] 2018; Hegmann et al [*ACOEM*] 2018, strength of evidence: no recommendation, insufficient evidence (I) / level of confidence). However, in the absence of findings on routine radiography, imaging options to evaluate ligamentous integrity include arthrography (Chang et al [*ACR*] 2018). MR arthrography can also be useful to assess chronic ankle instability, while CT arthrography has shown accuracy of 71% for diagnosing anterior talofibular ligament pathology (Chang et al [*ACR*] 2018). MR arthrography has been found to be an accurate method for assessment of both anterolateral and anteromedial impingement (Chang et al [*ACR*] 2018).

Bone scan
Bone scan is not routinely used for evaluation of chronic ankle sprain, ligamentous integrity, or suspected tendon abnormality (Chang et al [*ACR*] 2018; Hegmann et al [*ACOEM*] 2018, strength of evidence: no recommendation, insufficient evidence (I) / level of confidence: low pg 208). However, a 3-phase bone scan may be useful in cases of suspected complex regional pain syndrome, though its diagnostic capability varies in the literature (Tafur et al [*ACR*] 2020). Bone scan combined with SPECT/CT has been found to be of use when investigating impingement syndrome, soft tissue pathology, or heel pain, with increased specificity compared to bone scintigraphy alone (Tafur et al [*ACR*] 2020; Chang et al [*ACR*] 2018). Yet despite the anatomic and functional advantages of SPECT/CT, MRI and high-frequency ultrasound remain the most frequently used imaging modalities in patients with heel pain (Tafur et al [*ACR*] 2020; Hegmann et al [*ACOEM*] 2018, strength of evidence: not recommended, insufficient

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evidence (I) / level of confidence).

Ultrasound

Ultrasound is not usually a first line imaging study for evaluating chronic foot pain but may be useful for suspected pathologic conditions of the Achilles tendon, plantar fascia, and other conditions such as tarsal tunnel syndrome (Tafur et al [*ACR*] 2020). In the absence of findings on routine radiography, ultrasound may be an option to evaluate for ligamentous integrity (Chang et al [*ACR*] 2018).

Clinical/Imaging notes:

- Ultrasound for chronic ankle instability or assessment of ankle sprain that has not demonstrated improvement in 4-6 weeks may be reasonable, although there is insufficient information to recommend it over CT or MRI (Hegmann et al [*ACOEM*] 2018).
- Although diagnosing non-rupture Achilles disorders is largely based on a careful history and examination, diagnostic imaging may be required to verify a clinical suspicion or to exclude other musculoskeletal disorders (Hegmann et al [*ACOEM*] 2018):
- Ultrasound may be the initial step for imaging of plantar fasciitis, particularly when clinical diagnosis is uncertain or after no improvement from a course of conservative treatment (Bussieres et al 2007; Hegmann et al [*ACOEM*] 2018).
- In addition to the diagnostic capabilities of ultrasound, when a tendon abnormality or impingement syndrome is detected, a fluoroscopic or ultrasound-guided injection may be appropriate (Chang et al [*ACR*] 2018).
- Ultrasound imaging should be conducted by qualified personnel and with proper equipment (PLE expert panel consensus opinion).

Evidence update (2017 - present):

Moderate Level of Evidence

Drake et al (2022) conducted a systematic review and meta-analysis to synthesize medical imaging features associated with plantar heel pain. A total of 42 studies (n = 2,928) were identified and included in the analysis. Study quality and risk of bias was assessed, and sensitivity analyses were conducted where appropriate. Only 21% of studies were rated “good” on quality assessment. Imaging features associated with plantar heel pain were a thickened plantar fascia (on ultrasound and MRI), abnormalities of the plantar fascia (on ultrasound and MRI), abnormalities of adjacent tissue such as thickened loaded plantar heel fat pad (on ultrasound), and plantar calcaneal spur (on radiographs). The authors conclude that while these medical imaging features may aid with diagnosis, additional high-quality studies investigating imaging findings would be worthwhile to improve precision.

Low Level of Evidence

Cao et al (2018) conducted a systemic review with meta-analysis to analyze studies on diagnostic accuracy of different imaging techniques of chronic lateral ligament injury, using arthroscopic or surgical findings as the gold standard. Fifteen studies with a total of 695 participants were included. Data were extracted to calculate pooled sensitivity and specificity of MRI, ultrasonography (US), stress radiography, and arthrography. Pooled sensitivities in diagnosing chronic anterior talofibular ligament (ATFL) injury were 0.83 [0.78, 0.87] for MRI, 0.99 [0.96, 1.00] for US, and 0.81 [0.68, 0.90] for stress radiography. Pooled specificities in diagnosing chronic ATFL injury were 0.79 [0.69, 0.87] for MRI, 0.91 [0.82, 0.97] for US, and 0.92 [0.79, 0.98] for stress radiography. Pooled sensitivities in diagnosing chronic calcaneofibular ligament (CFL) injury were 0.56 [0.46, 0.66] for MRI, 0.94 [0.85, 0.98] for US, and 0.90 [0.73, 0.98] for arthrography. Pooled specificities in diagnosing chronic CFL injury were 0.88 [0.82, 0.93] for MRI, 0.91 [0.80, 0.97] for US, and 0.90 [0.77, 0.97] for arthrography. The authors conclude that US

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manifested high diagnostic accuracy in diagnosing chronic lateral ankle ligament injury, and that clinicians should be aware of MRI's limitations in detecting chronic CFL injuries.

Tan et al (2017) evaluated the accuracy of MRI in diagnosing lateral ankle ligament injuries and the effect of differences in time duration from injury to MRI. 82 patients with residual symptoms of ankle pain, swelling, or instability after > 6 weeks of conservative treatment were included. Patients were divided into acute (< 3 months) or chronic (> 3 months) groups based on injury interval. Findings were classified as normal, partial, or complete tears of the ATFL and the CFL. The accuracy of MRI for partial and complete tears of the ATFL was 74% and 79%, respectively, with sensitivity and specificity of 64% and 86% for partial tears, and 78% and 80% for complete tears, respectively. Accuracy of MRI was 66% and 88% for partial and complete tears of the CFL with a sensitivity and specificity of 41% and 87% for partial tears, and 61% and 95% for complete tears, respectively. A decrease in MRI accuracy was observed in the chronic group. The authors conclude that MRI is accurate in diagnosing ATFL injuries, and it is specific but not sensitive for CFL tears. The accuracy is higher in the acute setting of 3 months or less from time of injury to MRI.

Kim et al (2015) analyzed the reliability and validity of MRI for detection of anterior talofibular ligament (ATFL) injuries in chronic lateral ankle instability by comparing its findings with arthroscopic findings. 79 patients who underwent MRI followed by subsequent arthroscopy for various ankle disorders were included. On arthroscopy, 55 ATFL injuries were identified. The interobserver reliability of detecting ATFL injuries with MRI was excellent (intraclass correlation coefficient, 0.915). MRI, as interpreted by readers A and B, showed a sensitivity of 83.6% and 76.4%, respectively; specificity of 91.7% and 83.3%, respectively; negative predictive value of 71.0% and 60.6%, respectively; positive predictive value of 95.8% and 91.3%, respectively; and accuracy of 86.1% and 78.5%, respectively. The authors conclude that MRI has excellent interobserver reliability for detecting ATFL injuries in patients in whom there is a clinical suspicion of chronic lateral ankle instability.

Ozer et al (2019) sought to determine a possible relationship between ankle impingement syndrome and prevalence of os trigonum and osteochondral lesions of talus (OCLT). 333 patients clinically considered to be diagnosed with ankle impingement syndrome and had ankle MRI were included. Patients had no history of major ankle trauma, and had persistence of complaints after > 3 weeks of conservative treatment. Presence of anterior ankle impingement syndrome (AAIS), posterior ankle impingement syndrome (PAIS), os trigonum, OCLT, and location of OCLT were evaluated. The prevalence of os trigonum was 1.3% in patients with PAIS(-) AAIS(+), 7.7% in patients with PAIS(-) AAIS(-), 63.3% in patients with PAIS(+) AAIS(-), and 81.1% in patients with PAIS(+) AAIS(+) (p < .001). The prevalence of OCLT was 41.3% in patients with PAIS(-) AAIS(+), 23.1% in patients with PAIS(-) AAIS(-), 18.3% in patients with PAIS(+) AAIS(-), and 27% in patients with PAIS(+) AAIS(+) (p= .005). The authors conclude that, in patients with isolated PAIS and in AAIS combined with PAIS, the prevalence of os trigonum was 63.3% and 81.1%, respectively, which is more common than previously reported.

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Osteoarthritis of the ankle and/or hindfoot on conventional radiography with <u>any</u> of the following:

- **New-onset severe pain**
- **Significant worsening of symptoms**
- **Pain that is disproportionate to findings on repeat radiography**
- **Pre-surgical planning**

- **Green – MRI without IV contrast**
- **Green – CT without IV contrast**
- **Yellow – CT arthrography**
  [patient unable to undergo MRI; pre-surgical planning]
- **Yellow – MR arthrography**
  [pre-surgical planning]
- **Red – MRI without and with IV contrast**, **CT with IV contrast**, **CT without and with IV contrast**, **bone scan**, **SPECT**, **PET**, **PET/CT**

<u>Level of Evidence:</u> MRI without contrast: moderate; CT without contrast: very low; MRI without and with contrast, MRI with contrast, CT with contrast, CT without and with contrast, MR arthrography, CT arthrography, PET/CT: insufficient

<u>Notes concerning applicability and/or patient preferences:</u>
None

<u>Guideline and PLE expert panel consensus opinion summary:</u>
Advanced imaging is not recommended for the routine diagnosis, management, or follow-up of typical osteoarthritis of the ankle (Sakellariou et al [*EULAR*] 2017). Typical presentation includes common symptoms such as usage-relate pain, short-duration morning stiffness, age > 40, and symptoms affecting one or a few joints (Sakellariou et al [*EULAR*] 2017: level III-IV evidence, level of agreement: 8.7). Rather, conventional radiography is useful for the diagnosis and evaluation of osteoarthritis in such patients, including those with gradual onset or progression of symptoms (PLE expert panel consensus opinion).

In atypical presentations, imaging is recommended to help confirm the diagnosis of OA and/or make alternative or additional diagnoses (Sakellariou et al [*EULAR*] 2017; level IV evidence; level of agreement: 9.6). While routine imaging in osteoarthritis follow-up is not recommended, imaging is also recommended if there is unexpected rapid progression of symptoms or changes in clinical characteristics to determine if this relates to osteoarthritis or an additional diagnosis (Sakellariou et al [*EULAR*] 2017; level III-IV evidence; level of agreement: 8.8). If imaging is needed, conventional radiography should be used before other modalities. To make additional diagnoses, soft tissues are best imaged by ultrasound or MRI and bone by CT or MRI (Sakellariou et al [*EULAR*] 2017; level III-IV evidence; level of agreement: 8.7).

When degenerative changes of the ankle joint are diagnosed based on radiographs, MRI may be considered as the next best examination to evaluate cartilage integrity, bone marrow, and associated

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soft tissues, such as ligaments and tendons (Chang et al [*ACR*] 2018). In those with chronic pain and multiple sites of degenerative joint disease in the hindfoot detected by ankle radiographs, CT without IV contrast may be helpful to visualize subchondral cysts (Chang et al [*ACR*] 2018). MR arthrography and CT arthrography are not routinely used for the evaluation of degenerative joint disease (Chang et al [*ACR*] 2018). However, in patients with atypical presentations, such as rapid progression of symptoms or changes in the clinical characteristics, CT arthrography may be considered if the patient is unable to undergo MRI (PLE expert panel consensus opinion). MRI without IV contrast, CT without IV contrast or CT arthrography may be useful for surgical planning in patients considering ankle arthroplasty or chondroplasty (PLE expert panel consensus opinion), while MR arthrography or CT arthrography may be considered for those considering partial ankle arthroplasty or chondroplasty (PLE expert panel consensus opinion).

Clinical/Imaging notes:

- According to current evidence, imaging features do not predict non-surgical treatment response and imaging cannot be recommended for this purpose (Sakellariou et al [*EULAR*] 2017).
- Ultrasound is not routinely used for the evaluation of degenerative joint disease (Chang et al [*ACR*] 2018).

Evidence update (2017 - present):

There were no new articles that significantly affected the recommendations or conclusions found in the guidelines referenced above.

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Ankle and/or hindfoot pain with suspicion for osteochondral defect or subchondral osteonecrosis (avascular necrosis) following radiographs:

- Green – **MRI without IV contrast**
- Yellow - **MRI without and with IV contrast**
- Yellow – **CT without IV contrast**
  [pre-surgical planning; or patient is unable to undergo MRI]
- Yellow – **Bone scan** (with or without **SPECT** or **SPECT/CT**)
  [patient unable to undergo MRI; or previous findings on MRI without IV contrast are non-diagnostic]
- Yellow – **CT arthrography**
  [assess for instability, cartilage abnormality, or intra-articular bodies]
- Yellow – **MR arthrography**
  [assess for instability, cartilage abnormality, or intra-articular bodies]
- Red – **CT with IV contrast**, **CT without and with IV contrast**, **PET**, **PET/CT**

Level of Evidence: MRI without contrast: moderate; CT without contrast, MR arthrography, CT arthrography, bone scan with SPECT/CT: low; MRI without and with contrast, CT with contrast, CT without and with contrast, CT with contrast, PET/CT: insufficient

Notes concerning applicability and/or patient preferences:
Nuclear medicine studies fused with CT are not yet widely available, and therefore may have applicability or generalizability issues in the community outpatient setting (PLE expert panel consensus opinion).

Guideline and PLE expert panel consensus opinion summary:

Conventional Radiography

Radiography should be considered as the initial imaging study and may reveal osteochondral abnormalities (Chang et al [*ACR*] 2018). However, radiography often fails to show the extent of the osteochondral injury and will be initially negative if limited to the articular hyaline cartilage (Chang et al [*ACR*] 2018). Radiography is also beneficial as the initial imaging study for clinically suspected osteonecrosis (Ha et al [*ACR*] 2022). While less sensitive for detecting early osteonecrosis, radiographs are useful to exclude other causes of pain and can show findings of secondary osteoarthritis in late-stage osteonecrosis (Ha et al [*ACR*] 2022).

MRI

MRI of the ankle without IV contrast should be the next imaging study for suspected osteochondral lesion when ankle radiographs are normal, with excellent sensitivity and specificity (Chang et al [*ACR*] 2018; Vuurberg et al 2018). It is the study of choice for assessing cartilage abnormalities and bone contusions related to osteochondral lesion, particularly in those with persistent pain, stiffness, locking, clicking, or ankle swelling (Smith et al [*ACR*] 2020). MRI without IV contrast is also the most sensitive and specific imaging modality for osteonecrosis diagnosis, with a sensitivity and specificity near 100% (Ha et al [*ACR*] 2022; Bussieres et al 2007). In patients with hindfoot pain, MRI can exclude osteonecrosis of the talar dome (Hegmann et al [*ACOEM*] 2018; strength of evidence: recommended, insufficient evidence (I), level of confidence: moderate). MRI without and with IV contrast can be useful to differentiate osteonecrosis from transient bone marrow edema syndrome and subchondral insufficiency fracture (Ha et al [*ACR*] 2022).

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CT
While MRI is regarded as the reference standard osteochondral injuries, CT can be useful on a case-by-case basis to identify, locate and quantify cortical and subcortical involvement or loss, osteochondral abnormalities, and the presence of intra-articular ossific bodies (Smith et al [*ACR*] 2020; Talfur et al [*ACR*] 2020; Bussieres et al 2007). CT is less sensitive than bone scan or MRI for early osteonecrosis detection but is superior to MRI in showing location and extent of articular collapse and osseous details of secondary osteoarthritis (Ha et al [*ACR*] 2022). CT also plays a critical role in surgical planning (Ha et al [*ACR*] 2022).

Bone Scan (with SPECT or SPECT/CT)
When osteochondral injuries are associated with fracture, osseous cyst, or osteochondral defect, bone scan (with SPECT or SPECT/CT) may show the abnormality (Chang et al [*ACR*] 2018). In recent years, bone scan has been replaced by MRI for detecting osteonecrosis due to poor spatial resolution, low specificity and inability to quantify lesion size (Ha et al [*ACR*] 2022). However, it may be useful on a case-by-case basis if the patient is unable to receive MRI (Bussieres et al 2007), particularly with the addition of SPECT, which may improve accuracy (Ha et al [*ACR*] 2022).

MR Arthrography or CT Arthrography
The introduction of contrast into the ankle joint prior to CT or MRI will outline a cartilage surface defect, which can assist in lesion detection and assessment for instability (Chang et al [*ACR*] 2018). CT arthrography has been reported to have higher accuracy than MR arthrography for talar cartilaginous lesions (Chang et al [*ACR*] 2018).

PET/CT
Early limited data for PET/CT have not been shown to be useful in diagnosis of early osteonecrosis (Ha et al [*ACR*] 2022).

<u>Clinical/Imaging notes:</u>

- Osteochondral injuries may involve the talar dome and, less commonly, the tibial plafond and tarsal navicular bone (Chang et al [*ACR*] 2018).
- Osteonecrosis is defined as bone death due to inadequate vascular supply and can be caused by vascular interruption, vascular occlusion, or extravascular intraosseous compression (Ha et al [*ACR*] 2022).
- Early diagnosis of osteonecrosis is important to exclude other causes of pain and to allow for possible early surgical prevention. Imaging is also important for preoperative planning (Ha et al [*ACR*] 2022).

<u>Evidence update (2016 – Present):</u>
Low Level of Evidence
Koc and Karabiyik (2018) investigated pathologies of main ligaments and tendons that support the foot arch in sprained ankles, by reviewing MRI studies and comparing the results in two groups of patients, with and without osteochondral lesions of the talus (OCLT). Images from 316 ankle sprain patients (158 with OCLT and 158 without OCLT) were evaluated by two musculoskeletal radiologists for pathologic findings. Results found that plantar fascia, short plantar ligament, and spring ligament abnormalities were seen in 50 (31.6%), 28 (17.7%), and 60 (38%) patients with OCLT, vs. nine (5.6%), three (1.9%), and 18 (11.4%) without OCLT, respectively. They conclude that these abnormalities were commonly seen on MRI in patients with OCLT.

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You et al (2016) evaluated prevalence and common location of coexisting osteochondral lesion of the distal tibia and fibula and associated abnormalities of ankle ligaments and tendons on MRI in 297 patients with an osteochondral lesion of the talus (OLT). Two readers reviewed the MRIs independently for presence of an osteochondral lesion of the distal tibia and fibula and for concomitant ligament and tendon injuries. Readers A and B identified 61 (20.5%) and 47 (15.8%) coexisting osteochondral lesions of the distal tibia and fibula, respectively, with good interobserver ($\kappa = 0.73$) and excellent intraobserver ($\kappa = 0.97$) reliabilities. Frequency of osteochondral lesions of the distal tibia and fibula was not significantly different according to location or stage of OLT. Abnormalities in the tibialis posterior tendon and in the anterior and posterior talofibular, calcaneofibular, and deltoid ligaments were significantly more common in patients with a coexisting osteochondral lesion of the distal tibia and fibula than in those with an isolated OLT ($p < 0.05$). The authors conclude that a coexisting osteochondral lesion of the distal tibia and fibula is not rare on MRI in patients with an OLT and is related to a higher frequency of concomitant ankle ligament and tendon injuries.

Kirschke et al (2016) sought to retrospectively determine the diagnostic value and reliability of CT arthrography (CTA) of the ankle in the evaluation of osteochondral defects, in comparison to conventional MRI. 79 patients had CTA and MRI of the ankle; in 17 cases, surgical reports with statements on cartilage integrity were available. Cartilage lesions and bony defects at talus and tibia were scored by two radiologists. On CTA, 41/79 and 31/79 patients had full thickness cartilage defects at the talus and at the tibia, respectively. MRI detected 54% of these defects. For the detection of full thickness cartilage lesions, interobserver agreement was substantial (0.72 ± 0.05) for CTA and moderate (0.55 ± 0.07) for MRI. In surgical reports, 88–92% and 46–62% of full thickness defects detected by CTA and MRI were described. CTA findings changed the further clinical management in 15.4% of cases. The authors conclude that, compared to conventional MRI, CTA improves detection and visualization of cartilage defects at the ankle and is a relevant tool for treatment decisions in unclear cases.

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Suspicion for ankle and/or hindfoot septic arthritis, osteomyelitis, or Charcot arthropathy and non-diagnostic radiographs:

- Green – **MRI without and with IV contrast**
- Green – **MRI without IV contrast**
- Yellow – **CT with IV contrast**
- Yellow – **CT without IV contrast**
- Yellow – **Bone scan** and/or **WBC scan** (with or without **sulfur colloid marrow scan** and/or **SPECT** or **SPECT/CT**)
  [patient unable to undergo MRI; or findings on previous MRI are non-diagnostic]
- Yellow – **FDG-PET** or **FDG-PET/CT**
  [patient unable to undergo MRI; or findings on previous MRI are non-diagnostic]
- Red – **CT without and with IV contrast**, **MR arthrography**, **CT arthrography**

Level of Evidence: MRI without contrast, MRI without and with contrast: moderate; CT without contrast, bone scan, WBC scintigraphy, FDG-PET/CT, CT with contrast: low; MRI with contrast, MR arthrography, CT without and with contrast, CT arthrography: insufficient

Notes concerning applicability and/or patient preferences:
Nuclear medicine studies fused with CT are not yet widely available, and therefore may have applicability or generalizability issues in the community outpatient setting (PLE expert panel consensus opinion).

Guideline and PLE expert panel consensus opinion summary:
Conventional Radiography
Radiographs are the initial evaluation of choice for musculoskeletal infections, including osteomyelitis, septic arthritis, and soft tissue infection (Pierce et al [*ACR*] 2022). They are also recommended for diagnostic testing of Charcot joint (neurogenic arthropathy) (Hegmann et al [*ACOEM*] 2018; *NICE* 2019). Radiographs in those with a new diabetic foot infection can be used to provide an excellent overview of the anatomic area, and look for bony abnormalities (deformity, destruction) as well as for soft tissue gas, radio-opaque foreign bodies, fractures, tumors, and other causes of pain (Lipsky et al [*IDSA*] 2012; Hingorani et al [*SVS*] 2016; Hegmann et al [*ACOEM*] 2018; Walker et al [*ACR*] 2019; *NICE* 2019; Pierce et al [*ACR*] 2022). If radiographs and clinical and laboratory findings are most compatible with osteomyelitis, no further imaging is recommended to establish the diagnosis (Lipsky et al [IWGDF] 2019: strong recommendation, low level of evidence). However, osteomyelitis may be present in those with diabetes and normal radiographs (*NICE* 2019). Depending on the patient setting, advanced imaging for diagnosing osteomyelitis is not needed in many patients (Lipsky et al [*IWGDF*] 2019; Walker et al [*ACR*] 2019). If the diagnosis of osteomyelitis remains in doubt, advanced imaging may be considered (Lipsky et al [*IWGDF*] 2019: strong recommendation, moderate level of evidence).

MRI
MRI is recommended as the study of choice when more sensitive or specific imaging is needed or when diagnosis remains uncertain (Lipsky et al [*IDSA*] 2012: strong recommendation, moderate level of evidence; Hingorani et al [*SVS*] 2016: grade 1B). With high sensitivity and specificity, MRI has been the most widely used test for decades (Lipsky et al [*IWGDF*] 2019; Walker et al [*ACR*] 2019; Pierce et al [*ACR*] 2022). MRI is useful to evaluate musculoskeletal soft tissue infection because of a high sensitivity to fluid and inflammation, with excellent detection of the extent of both superficial and deep soft tissue infection (Pierce et al [*ACR*] 2022). If osteomyelitis is suspected but not confirmed by initial radiographs,

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MRI can be considered to confirm the diagnosis (*NICE* 2019; Lipsky et al [*IDSA*] 2012: strong recommendation, low level of evidence). MRI should also be considered if the radiographs are normal but Charcot arthropathy is still suspected (*NICE* 2019). MRI with or without contrast enhancement demonstrates excellent soft tissue contrast and sensitivity to marrow abnormalities (Walker et al [*ACR*] 2019). It can also identify other potential sources of pain, such as soft-tissue infection, tumor, abscess, early neuropathic arthropathy, and subtle fractures (Walker et al [*ACR*] 2019). IV contrast administration is preferred to help evaluate the soft tissues, and contrast-enhanced MRI can further increase the diagnostic sensitivity for abscess, fistula, and vascular complications (Pierce et al [*ACR*] 2022). Compared with CT, however, soft tissue gas is not well-visualized on MRI (Pierce et al [*ACR*] 2022). While MRI is susceptible to metallic artifact from indwelling hardware, metal reduction sequences are able to mitigate this as a limitation (Pierce et al [*ACR*] 2022).

Bone scan and/or WBC scan (with or without sulfur colloid scan and/or SPECT or SPECT/CT)
In general, nuclear medicine examinations can be useful in cases where MRI is contraindicated, infection is multifocal, or when the infection is associated with orthopedic hardware, chronic bone alterations from trauma or surgery, or suspected bony involvement for foot ulcer (Walker et al [*ACR*] 2019; Hegmann et al [*ACOEM*] 2018: strength of evidence: recommended, insufficient evidence (I)). While radionuclide scans, such as 3-phase bone scan, WBC scan, or sulfur colloid scan can be ordered to increase the accuracy of diagnosing osteomyelitis, they have poor spatial resolution and low specificity for diagnosing septic arthritis or soft-tissue infection (Pierce et al [*ACR*] 2022). A 3-phase bone scan is also sensitive but not specific for differentiating osteomyelitis from neuropathic foot (Walker et al [*ACR*] 2019). For these reasons, the combination of a radionuclide bone scan and a WBC scan can be considered as the best alternative (Lipsky et al [*IDSA*] 2012: weak recommendation, low level of evidence).

Sulfur colloid scan may also be considered if 3-phase and WBC scans are non-diagnostic (Pierce et al [*ACR*] 2022). If a 3-phase bone scan is positive, also obtaining both a WBC scan and sulfur colloid scan may further increase specificity (Pierce et al [*ACR*] 2022). A 3-phase bone scan combined with WBC scan and sulfur colloid marrow scan can be helpful when significant metal hardware is present that would impair MRI or CT imaging (Walker et al [*ACR*] 2019). In patients with orthopedic hardware, WBC scan in combination with sulfur colloid scan may be useful to assess osteomyelitis (Walker et al [*ACR*] 2019). Combining a sulfur colloid scan with a WBC scan may reduce false positive results from normal WBC accumulation in bone marrow adjacent to orthopedic hardware (Pierce et al [*ACR*] 2022).

SPECT/CT-fused imaging improves diagnostic accuracy, and the addition of SPECT/CT imaging may also increase ability to localize infection in cases with orthopedic hardware (Pierce et al [*ACR*] 2022). Its addition is recommended in positive WBC studies for more accurate localization and to help differentiate soft tissue infection from osteomyelitis (Pierce et al [*ACR*] 2022).

CT
CT with or without IV contrast demonstrates the features of acute osteomyelitis in more detail than radiographs but is less sensitive than MRI or nuclear medicine studies for detecting early intramedullary changes (Pierce et al [*ACR*] 2022; Walker et al [*ACR*] 2019). However, compared with ultrasound and MRI, CT is the most sensitive modality for detection of soft tissue gas (Pierce et al [*ACR*] 2022). CT is useful to evaluate soft tissue compartments and can help to differentiate cellulitis, myositis, tenosynovitis, abscess, and septic arthritis (Pierce et al [*ACR*] 2022). Contrast-enhanced CT improves the assessment for abscess, tissue necrosis, vascular complications, and extent of infection (Pierce et al [*ACR*] 2022). CT is useful to evaluate postsurgical complications such as hardware fracture,

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periprosthetic osteolysis, and fracture nonunion (Pierce et al [*ACR*] 2022). Features of chronic osteomyelitis are well depicted on CT with or without IV contrast (Walker et al [*ACR*] 2019). There is no additional benefit in performing a CT without and with IV contrast (Pierce et al [*ACR*] 2022).

FDG-PET/CT

FDG-PET/CT has a potentially important role in diagnosing deep soft-tissue infection and osteomyelitis and differentiating neuropathic arthropathy (Walker et al [*ACR*] 2019). FDG PET/CT has high sensitivity and specificity for detecting osteomyelitis, however a recent fracture or orthopedic implant may lower its accuracy (Pierce et al [*ACR*] 2022). Fused FDG-PET/CT allows correct differentiation between osteomyelitis and soft-tissue infection (Walker et al [*ACR*] 2019). It can also be used to evaluate those with metal implants that would compromise the accuracy of MRI or CT (Walker et al [*ACR*] 2019).

<u>Clinical/imaging notes:</u>

- Diabetic foot osteomyelitis and neuroarthropathy can be difficult to differentiate clinically (Walker et al [*ACR*] 2019).
- If a person with diabetes has a local infection, a deep foot wound, or a chronic foot would, osteomyelitis should be considered (*NICE* 2019).
- Clinical features that suggest osteomyelitis include ulcer area > 2 cm^2, elevated erythrocyte sedimentation rate level of > 70 mm/hr, positive probe-to-bone test, nonhealing ulcer for 6 months, erythema, fever, and elevated WBC count (Walker et al [*ACR*] 2019).
- Clinicians might consider using serial plain radiographs to diagnose or monitor suspected diabetic foot osteomyelitis (Lipsky et al [*IDSA*] 2012; Hingorani et al [*SVS*] 2016).
- In those with diabetes and suspected osteomyelitis of the foot, using a combination of the probe-to-bone test, the erythrocyte sedimentation rate (or C-reactive protein and/or procalcitonin), and plain radiographs are recommended as the initial studies to diagnose osteomyelitis (Lipsky et al [*IDSA*] 2012).
- Ultrasound is a useful methodology for detecting fluid, such as joint effusion, abscess and infected tendon sheaths (Pierce et al [*ACR*] 2022) but is of limited benefit compared to MRI or CT in detection of osteomyelitis because of its inability to penetrate the cortex of the bone (Walker et al [*ACR*] 2019; Pierce et al [*ACR*] 2022).

<u>Evidence update (2017 - present):</u>

High Level of Evidence

Llewellyn et al (2019), in a health technology assessment systematic review, examined the evidence on the diagnostic accuracy, interrater reliability, and implementation of imaging tests to diagnose osteomyelitis. A total of 81 studies were included, and risk of bias was assessed with QUADAS-2. One-quarter of diagnostic accuracy studies were rated as being at high risk of bias. In adults, MRI had high diagnostic accuracy (95.6% sensitivity, 95% CI, 92.4%-97.5%; 80.7% specificity, 95% CI, 80.8%-87.8%). PET also had high accuracy (85.1% sensitivity, 95%CI 71.5%-92.9%; 92.8% specificity, 95% CI, 83%-97.1%), as did SPECT (95.1% sensitivity, 95% CI, 87.8%-98.1%; 82% specificity. 95% CI, 61.5%-92.8%). There was similar diagnostic performance with MRI, PET and SPCT. Scintigraphy (83.6% sensitivity, 95% CI 71.8%-91.1%; 70.6% specificity, 95% CI, 57.7%-80.8%), computed tomography (69.7% sensitivity, 95% CI, 40.1%-88.7%; 90.2% specificity, 95% CI, 57.6%-98.4%), and radiography (70.4% sensitivity, 95% CI, 61.6%-77.8%; 81.5% specificity, 95% CI, 69.6%-89.5%) all had generally inferior diagnostic accuracy. Tc99m hexamethylpropyleneamine oxime white blood cell scintigraphy (87.3% sensitivity, 95% CI 75.1%-94%; 94.7% specificity, 95% CI, 84.9%-98.3%) had higher diagnostic accuracy, similar to that of PET or MRI. There was no evidence that diagnostic accuracy varied by scan location or cause of osteomyelitis,

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although data on may scan locations was limited. Diagnostic accuracy in diabetic foot patients was similar to the overall results.

Moderate Level of Evidence

Llewellyn et al (2020), in a systematic review and meta-analysis, reviewed the evidence on the diagnostic accuracy of imaging tests to diagnose osteomyelitis in people with diabetic foot ulcers. A total of 36 studies were included in the meta-analysis. Risk of bias was evaluated, and eight studies were found to be at high risk of bias. Results found that MRI had high diagnostic accuracy (96.4% sensitivity, 95% CI 90.7%-98.7%; 83.8% specificity, 95% CI, 76%-89.5%). PET scans also had high accuracy (84.3% sensitivity, 95% CI 52.8%-96.3%; 92.8% specificity, 95% CI 75.7%-98.2%). SPECT also possibly had high accuracy, but with few studies examined (95.6% sensitivity, 95% CI 76-99.3%; 55.1% specificity, 95% CI 19.3%-86.3%). Scintigraphy (84.2% sensitivity, 95% CI 76.8%-89.6%; 67.7% specificity, 95% CI 56.2%-77.45) and radiography (61.9% sensitivity, 95% CI 50.5%-72.1%; 78.3% specificity, 95% CI 62.9%-88.5%) had generally inferior diagnostic accuracy. The authors conclude that this review confirms most current guidelines, showing that MRI may be the preferable test in most cases, given its wider availability and lack of potentially harmful ionizing radiation.

Low Level of Evidence

Liao et al (2018) investigated the diagnostic value of dynamic contrast-enhanced MRI (DCE-MRI) in differentiating osteomyelitis from acute neuropathic arthropathy in the diabetic foot. 30 patients (mean age 51) underwent clinical exam, labs, and DCE-MRI. The DCE-MRI parameters (Ktrans, Kep and Ve) of the regions of acute neuropathic arthropathy and osteomyelitis were calculated. Ktrans, Kep and Ve values of the osteomyelitic regions were higher than those of the acute neuropathic arthropathy regions, and significant differences were found between groups. ROC analysis showed that Ktrans and Ve performed best in differentiating osteomyelitis from acute neuropathic arthropathy, both with area under the curve of 0.938. The authors conclude that DCE-MRI may provide reproducible parameters that can reliably differentiate osteomyelitis from acute neuropathic arthropathy. *The PLE expert panel noted that, although promising, this was a cohort study which may overstate the accuracy of the technique, and the availability of the technology may be limited* (PLE expert panel consensus opinion).

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Ankle and/or hindfoot pain with suspicion for foreign body, radiographs and/or ultrasound are non-diagnostic

- Green – **CT without IV contrast**
- Yellow – **MRI without IV contrast**
- Yellow – **MRI without and with IV contrast**
- Yellow – **CT with IV contrast**
  [patient unable to undergo MRI]
- Yellow – **CT without and with IV contrast**
  [patient unable to undergo MRI]
- Red – **Bone scan**, **SPECT**, **PET**, **PET/CT**, **MR arthrography**, **CT arthrography**

Level of Evidence: CT without contrast: moderate; MRI without contrast, MRI without and with contrast: low; bone scan; MRI with contrast, MR arthrography, CT arthrography, CT with contrast, CT without and with contrast, PET/CT: insufficient

Notes concerning applicability and/or patient preferences:
None

Guideline and PLE expert panel consensus opinion summary:
Both radiographs are ultrasound are useful imaging tools to exclude a foreign body in the setting of penetrating trauma to the foot (Gorbachova et al [*ACR*] 2019). Radiographs are indicated for initial imaging, especially if the composition of the material is unknown, and are well suited in detecting radiodense foreign bodies such as metal, graphite, and stone (Walker et al [*ACR*] 2019). If a foreign body is not seen on radiographs, ultrasound can be useful, with a reported sensitivity of 95% (Pierce et al [*ACR*] 2022). When appropriate expertise and equipment is available, ultrasound is the modality of choice if the foreign body is radiolucent (e.g., wood or plastic), with a 90% sensitivity for visualizing wooden foreign bodies (Walker et al [*ACR*] 2019; Gorbachova et al [*ACR*] 2019). Ultrasound can help to determine if there is tendon or muscle involvement and to evaluate for abscess (Gorbachova et al [*ACR*] 2019; PLE expert panel consensus opinion).

CT is reportedly 5-15 times more sensitive for detecting foreign bodies when compared to radiography (Pierce et al [*ACR*] 2022). It can visualize soft tissue gas and evaluate for complications of infection, such as cellulitis, edema, abscess, and vascular or tendon injury (Pierce et al [*ACR*] 2022). CT with or without IV contrast may be superior to MRI for the findings of foreign bodies in patients with diabetes and soft tissue swelling without ulcer (Walker et al [*ACR*] 2019). While CT can detect foreign bodies embedded in bone, it is not as sensitive as MRI for detection of bone marrow edema (Pierce et al [*ACR*] 2022).

Compared to ultrasound or CT, MRI has lower sensitivity and inferior spatial resolution for detecting foreign bodies, and small ones may be missed (Pierce et al [*ACR*] 2022). However, MRI can be used to help localize foreign bodies, and MRI with the addition of IV contrast can be useful to assess complications, such as cellulitis or abscess (Pierce et al [*ACR*] 2022). Radiographic screening for metallic foreign bodies is always recommended before MRI (Pierce et al [*ACR*] 2022).

Clinical/imaging notes:
- In patients with puncture wounds, a main goal of imaging is to determine the presence or absence of a retained foreign body (Pierce et al [*ACR*] 2022).

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- If MRI is used, GRE T2*-weighted or susceptibility weighted sequence should be added, as it is sensitive for blood products and microscopic metal, either of which may be helpful in locating an otherwise difficult to locate foreign body (PLE expert panel consensus opinion).

Evidence update (2016 - present):
There were no new articles that significantly affected the recommendations or conclusions found in the guidelines referenced above.

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Ankle and/or hindfoot pain with suspected or known hindfoot (tarsal) coalition following radiographs:

- Green – **MRI without IV contrast**
- Green – **CT without IV contrast**
- Yellow – **Bone scan** [with or without **SPECT** or **SPECT/CT**]
  [previous findings on MRI without IV contrast are non-diagnostic]
- Red – **CT with IV contrast**, **CT without and with IV contrast**, **MRI without and with IV contrast**, **PET**, **PET/CT**, **MR arthrography**, **CT arthrography**

Level of Evidence: MRI without contrast, CT without contrast: low-moderate; bone scan, SPECT/CT, MRI without and with contrast, MR arthrography, CT arthrography, CT with contrast, CT without and with contrast, PET/CT: insufficient

Notes concerning applicability and/or patient preferences:
Nuclear medicine studies fused with CT are not yet widely available, and therefore may have applicability or generalizability issues in the community outpatient setting (PLE expert panel consensus opinion).

Guideline and PLE expert panel consensus opinion summary:
In hindfoot-heel pain, radiographs can be used to exclude tarsal or calcaneonavicular coalition (Bussieres et al 2007; Tafur et al [*ACR*] 2020), with sensitivities ranging from 80%-100%, and specificities ranging from 97%-98% (Tafur et al [*ACR*] 2020). However, talocalcaneal or subtalar coalition may be overlooked on standard foot radiographs due to overlapping structures (Tafur et al [*ACR*] 2020). For this reason, sagittal CT and MRI scans remain the most reliable methods for confirming coalitions (Tafur et al [*ACR*] 2020; Chang et al [*ACR*] 2018), with MRI serving as the best investigation for differential diagnosis of tarsal tunnel syndrome, plantar fasciitis, tibialis posterior tenosynovitis, and tarsal coalition (Bussieres et al 2007). CT or MRI may also be appropriate for surgical planning in patients with known coalition (PLE expert panel consensus opinion). In patients with chronic pain and non-diagnostic radiographs, bone scan (with SPECT or SPECT/CT) may be useful for evaluation of ankle pathology and detection of tarsal coalition or painful accessory bones (Chang et al [*ACR*] 2018).

Clinical/imaging notes:

- Tarsal coalition is a congenital abnormality resulting from fibrous, cartilaginous, or osseous union of 2 or more tarsal bones; calcaneonavicular and middle-facet talocalcaneal coalitions are the most common (Wise et al [*ACR*] 2013).

Evidence update (2014 - present):
There were no new articles that significantly affected the recommendations or conclusions found in the guidelines referenced above.

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Guideline exclusions:

- Inflammatory arthritis (other than septic arthritis)
- Crystal deposition disease
- Metabolic bone disease
- Primary synovial abnormalities (e.g., PVNS, osteochondromatosis)
- Evaluation of indeterminate bone lesion and/or suspected neoplasm on radiograph
- Primary soft tissue neoplasm
- Lisfranc injuries
- CT navigation or modeling for ankle arthroplasty
- Painful ankle or hindfoot arthroplasty
- Pediatric patients
- Pregnant patients

AUC Revision History:

Revision Date:	New AUC Clinical Scenario(s):	Approved By:
11/19/2019	n/a	CDI Quality Institute's Multidisciplinary Committee
09/27/2022	n/a	RAYUS Quality Institute's Multidisciplinary Committee

Information on our evidence development process, including our conflicts of interest policy is available on our website at **https://rayusradiology.com/ple**

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Appropriateness of Advanced Imaging in Patients with Ankle and/or Hindfoot Pain Bibliography

09/27/2022

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