

**American College of Radiology
ACR Appropriateness Criteria®
Acute Trauma to the Foot**

Variant 1: Adult or child older than 5 years of age. Acute trauma to the foot. Ottawa rules can be evaluated without exclusionary criteria. Ottawa rules are negative. No suspected abnormalities in regions not evaluated by the Ottawa rules. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography foot	Usually Not Appropriate	☢
CT foot without IV contrast	Usually Not Appropriate	☢☢
CT foot with IV contrast	Usually Not Appropriate	☢☢
CT foot without and with IV contrast	Usually Not Appropriate	☢☢
MRI foot without IV contrast	Usually Not Appropriate	○
MRI foot without and with IV contrast	Usually Not Appropriate	○
US foot	Usually Not Appropriate	○

Variant 2: Adult or child older than 5 years of age. Acute trauma to the foot. Ottawa rules can be evaluated without exclusionary criteria. Ottawa rules are positive. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography foot	Usually Appropriate	☢
Radiography foot with weightbearing	Usually Appropriate	☢
CT foot with IV contrast	Usually Not Appropriate	☢☢
CT foot without and with IV contrast	Usually Not Appropriate	☢☢
CT foot without IV contrast	Usually Not Appropriate	☢☢
MRI foot without and with IV contrast	Usually Not Appropriate	○
MRI foot without IV contrast	Usually Not Appropriate	○
US foot	Usually Not Appropriate	○

Variant 3: Adult or child older than 5 years of age. Acute trauma to the foot. Ottawa rules cannot be evaluated due to exclusionary criteria. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography foot	Usually Appropriate	☢
CT foot without IV contrast	May Be Appropriate	☢☢
CT foot with IV contrast	Usually Not Appropriate	☢☢
CT foot without and with IV contrast	Usually Not Appropriate	☢☢
MRI foot without and with IV contrast	Usually Not Appropriate	○
MRI foot without IV contrast	Usually Not Appropriate	○
US foot	Usually Not Appropriate	○

Variant 4:

Adult or child older than 5 years of age. Acute trauma to the foot. Ottawa rules can be evaluated without exclusionary criteria. Ottawa rules are negative. Suspected pathology in an anatomic area not addressed by Ottawa rules (not involving the midfoot; eg, metatarsal-phalangeal joint, metatarsal, toe, tendon, etc). Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography foot	Usually Appropriate	⊕
Radiography foot with weightbearing	Usually Appropriate	⊕
CT foot without IV contrast	May Be Appropriate (Disagreement)	⊕⊕
CT foot with IV contrast	Usually Not Appropriate	⊕⊕
CT foot without and with IV contrast	Usually Not Appropriate	⊕⊕
Fluoroscopy foot	Usually Not Appropriate	⊕
MRI foot without and with IV contrast	Usually Not Appropriate	○
MRI foot without IV contrast	Usually Not Appropriate	○
US foot	Usually Not Appropriate	○

Variant 5:

Adult or child older than 5 years of age. Acute trauma to the foot. Suspect Lisfranc injury, tendon injury, or occult fracture or dislocation. Radiographs are normal or equivocal. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
CT foot without IV contrast	Usually Appropriate	⊕⊕
MRI foot without IV contrast	Usually Appropriate	○
US foot	May Be Appropriate	○
CT foot with IV contrast	Usually Not Appropriate	⊕⊕
CT foot without and with IV contrast	Usually Not Appropriate	⊕⊕
MRI foot without and with IV contrast	Usually Not Appropriate	○

Variant 6:

Adult or child older than 5 years of age. Acute trauma to the foot. Suspect penetrating trauma with a foreign body. Radiographs of the foot are negative. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
US foot	Usually Appropriate	○
CT foot without IV contrast	May Be Appropriate	⊕⊕
MRI foot without IV contrast	May Be Appropriate	○
CT foot with IV contrast	Usually Not Appropriate	⊕⊕
CT foot without and with IV contrast	Usually Not Appropriate	⊕⊕
MRI foot without and with IV contrast	Usually Not Appropriate	○

ACUTE TRAUMA TO THE FOOT

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Summary of Literature Review

Introduction/Background

Acute injuries to the foot are frequently encountered in the setting of the emergency room and in general practice. The clinical indications for imaging (known as the Ottawa rules) have been developed to minimize unnecessary radiographs, and their utility is well documented by multiple studies. The most commonly accepted form of these rules is the following:

A series of foot radiographs is required only if there is pain in the midfoot and any one of the following: 1) point bone tenderness of the navicular; 2) point bone tenderness of the base of the fifth metatarsal; or 3) inability to bear weight or to walk 4 steps (immediately after the injury or at the emergency department).

A meta-analysis (10 studies encompassing 3,725 patients) of the Ottawa rules for the foot showed that these rules have a sensitivity of 99% and a median specificity of 26% for combined evaluation of the ankle and midfoot [1]. The Ottawa rules for the ankle and midfoot have been shown to be effective for the pediatric population (>5 years of age) [2]. Including the added criterion of swelling yields a sensitivity and specificity for fracture of 100% and 55% for the malleolar zone and 50% and 40% for the midfoot, respectively [3,4].

Exclusionary Criteria

Multiple conditions or scenarios preclude the use of the Ottawa rules for determining if imaging is necessary [5,6]. It has been reported that the Ottawa rules for the foot should not be used or should be used with great caution in the following clinical situations: penetrating trauma, pregnancy, any skin wound, transferred with radiographs already taken, >10 days after trauma, a return visit for continued traumatic foot pain, in the setting of polytrauma, altered sensorium, neurologic abnormality affecting the foot, or underlying bone disease [7].

Other clinical scenarios of foot trauma not directly addressed by the Ottawa rules include trauma to the metatarsal heads and toes and penetrating trauma with concern for a foreign body in the soft tissues. Also, there is little in the literature on medical decision making of when to order a radiographic study of the toes [8].

Discussion of Procedures by Variant

Variant 1: Adult or child older than 5 years of age. Acute trauma to the foot. Ottawa rules can be evaluated without exclusionary criteria. Ottawa rules are negative. No suspected abnormalities in regions not evaluated by the Ottawa rules. Initial imaging.

When assessing acute trauma to the foot, it is very important to determine that there are no exclusionary criteria for evaluation by Ottawa rules, in which case the rules cannot be applied; see Variant 3. In addition, there are clinical scenarios that are not specifically assessed by the Ottawa rules because the rules mainly address injuries to the midfoot. Such scenarios, for example, include injuries to the forefoot; see Variant 4.

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The American College of Radiology seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply individual or society endorsement of the final document.

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Radiography Foot

The Ottawa rules were designed to minimize unnecessary radiographs for patients with acute ankle and foot injuries [6]. The Ottawa rules for acute trauma to the foot are fairly well established and have been validated by multiple institutional trials verifying the 99% sensitivity in determining the presence of a foot fracture [1,9,10]. The more serious potential problems in determining the need for imaging occurs in the patient who does not meet the inclusion criteria for imaging by the Ottawa rules of the foot. These inclusionary criteria are stated in the Introduction/Background section [5,6]; added criterion of swelling increases sensitivity and specificity [3,4]. One should carefully evaluate the patient to make sure they do not meet any of the exclusionary criteria before implementing the Ottawa rules. Radiographs may be appropriate in certain clinical scenarios when Ottawa rules cannot be applied. Also, trauma to the distal forefoot (metatarsal heads and toes) is not directly addressed by the Ottawa rules. In general, if a fracture of a toe is suspected, radiographs can document or rule out a fracture [11,12].

CT Foot

In this clinical scenario and in absence of exclusionary criteria for the Ottawa rules, CT is not routinely used as the first imaging study for the evaluation of acute trauma to the foot.

MRI Foot

MRI is not routinely used as the first imaging study for the evaluation of acute trauma to the foot.

US Foot

A preliminary ultrasound (US) study has had less successful results compared with radiographic evaluation, with 90.9% sensitivity and specificity for detecting fracture [13]. A recent consensus paper from the European Society of Musculoskeletal Radiology [14] assigned low grading scores for US assessment of talus and bony avulsions.

Variant 2: Adult or child older than 5 years of age. Acute trauma to the foot. Ottawa rules can be evaluated without exclusionary criteria. Ottawa rules are positive. Initial imaging.

Radiography Foot

Radiographs are indicated by positive Ottawa rules with 99% sensitivity in determining the presence of a foot fracture [1,9,10]. Radiographs are the mainstay of initial imaging in the setting of acute foot trauma. Initial imaging typically consists of a 3-view study with the possibility of additional views as indicated by the clinical setting [8]. Additional views, such as axial calcaneal view, can be useful in patients with suspected calcaneal fracture [15] because addition of this view increases specificity in diagnosing calcaneal fractures and sensitivity in distinguishing intra-articular calcaneal fractures.

Lisfranc Injury

When there is a fairly high clinical suspicion of an acute Lisfranc injury, the foot should be imaged. In addition to a typical 3-view radiographic study of the foot (anteroposterior [AP], oblique, and lateral), an AP view with 20° cranio-caudal angulation can be added [16,17]. Although patients with Lisfranc sprains may incur ligamentous damage without diastasis [18], radiography should be the initial imaging modality in the setting of a suspected Lisfranc injury.

Radiography Foot with Weightbearing

If there are clinical signs of a Lisfranc injury, obtaining weightbearing radiographs is recommended when possible because nonweightbearing radiographs are not reliable for detection of subtle injuries. Weightbearing views have been shown to increase the abnormal alignment at the Lisfranc joint, thus making it easier to identify a Lisfranc injury [16,19]. The inclusion of both feet on AP radiographs can help in the detection of subtle malalignment when compared with the uninjured side [20].

CT Foot

CT is commonly used in evaluating the true extent of osseous injury in complex fractures and at times is used as the initial imaging study in polytrauma patients and in complex regions such as the midfoot [21,22]. CT is not routinely used as the first imaging study for the evaluation of acute trauma to the foot with positive Ottawa rules when exclusionary criteria do not apply.

MRI Foot

MRI is not routinely used as the first imaging study for the evaluation of acute trauma to the foot with positive Ottawa rules.

US Foot

A preliminary US study had less successful results compared with radiographic evaluation, with 90.9% sensitivity and specificity for detecting fracture [13]. In the presence of localized tenderness, one study reported US sensitivity and specificity of 100% and 96% for fifth metatarsal fractures and 40% and 93% for navicular fractures, respectively [23]. A recent consensus paper from European Society of Musculoskeletal Radiology [14] assigned low grading scores for US assessment of talus and bony avulsions.

Variant 3: Adult or child older than 5 years of age. Acute trauma to the foot. Ottawa rules cannot be evaluated due to exclusionary criteria. Initial imaging.

Multiple conditions or scenarios preclude the use of the Ottawa rules for determining if imaging is necessary [5,6]. It has been reported that the Ottawa rules for the foot should not be used or should be used with great caution in the following clinical situations: penetrating trauma, pregnancy, any skin wound, transferred with radiographs already taken, >10 days after trauma, a return visit for continued traumatic foot pain, in the setting of polytrauma, altered sensorium, neurologic abnormality affecting the foot, or underlying bone disease [7].

Radiography Foot

If a foot fracture is suspected in a neurologically compromised patient, including patients with diabetic neuropathy, the foot should be radiographed. The Ottawa rules should not be applied in this clinical setting because pain perception may be diminished, no point tenderness will be elicited with palpation, and the patient may be able to ambulate even if a fracture is present [5]. Polytrauma and penetrating trauma also constitute exceptions to the implementations of the Ottawa rules.

Both radiographs and US are useful imaging tools to exclude a foreign body in the setting of penetrating trauma to the foot [24]. The best initial imaging study for a foreign body in the foot depends on whether or not the suspected foreign body is radiopaque (eg, gravel, both leaded and nonleaded glass, or metal). Radiographic evaluation for a radiopaque foreign body has approximately 98% sensitivity [25]. If an unembedded fragment of the foreign body is available, then imaging it alongside the foot might provide more information as to the morphology and density of the foreign body.

CT Foot

CT is commonly used in evaluating the true extent of osseous injury in complex fractures and at times is used as the initial imaging study in polytrauma patients and in complex regions such as the midfoot [21,22]. In the polytrauma patient, approximately 25% of midfoot fractures identified on CT are overlooked on radiographs [21]. Therefore, CT is essential for appropriate treatment planning and determining the true extent of osseous injuries in the polytrauma patient and can be used as primary imaging technique in high-energy polytrauma patients.

Initial clinical experience suggests that cone-beam CT of the foot or ankle of pediatric patients is a viable lower-dose alternative to multidetector CT [26].

MRI Foot

MRI is not routinely used as the first imaging study for the evaluation of acute trauma to the foot in the setting of peripheral neuropathy, penetrating trauma, or polytrauma.

US Foot

US is not routinely used as the first imaging study for the evaluation of acute trauma to the foot in the setting of peripheral neuropathy or polytrauma. Both radiographs and US are useful imaging tools to exclude a foreign body in the setting of penetrating trauma to the foot [24]. US is the imaging modality of choice if the foreign body is not radiopaque (eg, wood or plastic), with a reported 90% sensitivity for visualizing wooden foreign bodies in some clinical and experimental studies [27,28]. US can identify a foreign body and also help localize it and determine if it involves a tendon or a muscle and to evaluate for an abscess.

Variant 4: Adult or child older than 5 years of age. Acute trauma to the foot. Ottawa rules can be evaluated without exclusionary criteria. Ottawa rules are negative. Suspected pathology in an anatomic area not addressed by Ottawa rules (not involving the midfoot; eg, metatarsal-phalangeal joint, metatarsal, toe, tendon, etc). Initial imaging.

In clinical situations when Ottawa rules are applicable and negative, imaging may still be desired to evaluate for injuries not assessed by the Ottawa rules. For example, clinical scenarios of acute foot trauma not directly addressed by the Ottawa rules include trauma to the metatarsal heads and toes and acute tendon injury.

Radiography Foot

Metatarsal-Phalangeal Joint Injury

The best initial imaging study for evaluating hallux plantar plate disruption after metatarsal-phalangeal (MTP) joint injury is weightbearing AP, lateral, and sesamoid axial views, with addition of comparison radiographs of the contralateral foot [29]. Radiographs may also indirectly evaluate lesser metatarsophalangeal plantar plate injury [30]. The combination of a positive drawer test coupled with transverse deviation of the third MTP joint on radiographs can be used to diagnose high-grade plantar plate tear of the second MTP joint [31].

A forced dorsiflexion lateral view of the hallux MTP joint is recommended if there is clinical suspicion of plantar plate injury of the first MTP joint [29].

Radiography Foot with Weightbearing

The best initial imaging study for evaluating hallux plantar plate disruption after MTP joint injury is weightbearing AP, lateral, and sesamoid axial views with addition of comparison radiographs of the contralateral foot [29,32].

CT Foot

Studies report moderate to poor sensitivity (25%–33%) of radiographs in detection of midfoot fractures [21] in Level 1 trauma patients. A study of 49 patients with acute hyperflexion injuries to the foot concluded that conventional radiographs including weightbearing images are not sufficient for routine diagnostic workup and CT should serve as the primary imaging technique for such patients [33].

MRI Foot

MRI is the most sensitive modality for the detection of occult fracture and acute bone stress changes [34,35]. MRI is not routinely used as the first imaging study for the evaluation of acute trauma to the foot in setting of suspected MTP joint injury or occult fracture. Both MRI and US are used in evaluating soft-tissue injuries of the foot in the setting of acute trauma, especially when radiographs are noncontributory. Both modalities have a similar sensitivity for acute soft-tissue trauma about the ankle and foot such as ligamentous and tendinous disruption [36-38].

US Foot

US is not routinely used as the first imaging study for the evaluation of acute trauma to the foot in the setting of suspected MTP joint injury or occult fracture. US has been shown to be sensitive for the diagnosis of acute tendon rupture or tendon dislocation in the foot [36,39,40].

Fluoroscopy Foot

In addition to routine radiographs, fluoroscopy has been suggested in assessment of a hallux MTP joint injury with direct fluoroscopic evaluation of sesamoid tracking distally with great toe extension at the MTP joint on forced dorsiflexion lateral view or fluoroscopy [29].

Variant 5: Adult or child older than 5 years of age. Acute trauma to the foot. Suspect Lisfranc injury, tendon injury, or occult fracture or dislocation. Radiographs are normal or equivocal. Next imaging study.

CT Foot

Lisfranc Injury

CT has been advocated as the primary imaging technique in acute hyperflexion injury and high-energy polytrauma (especially if the patient is not able to bear weight) [33,38,41-45]. CT is useful in demonstrating the multiple metatarsal and cuneiform fractures that can be associated with a ligamentous Lisfranc injury [21,22,33]. CT is typically used for preoperative planning for fracture treatment and evaluation. In the patient with a suspected Lisfranc injury and normal radiographs, the literature supports further advanced imaging by MRI and CT [21,33,43,46].

Acute Tendinous Injury

CT imaging has been shown to be an effective way of documenting various tendon entrapment and dislocations, in particularly peroneal dislocations and peroneal retinacular injuries, which are associated with comminuted calcaneal fractures [47-50].

MRI Foot

MRI can show osseous injuries that are not visible radiographically including fractures and high-grade contusions associated with prolonged recovery times in elite athletes [51]. MRI can demonstrate ligamentous and osseous

injuries in midtarsal (Chopart) sprains, which frequently accompany acute ankle injuries [52,53]. If radiographs are negative, MRI can be obtained in select patients with forefoot pain because of its increased sensitivity for the early detection of metatarsal head subchondral fracture [54].

Lisfranc Injury

MRI has been advocated as a sensitive diagnostic test in evaluation of Lisfranc ligamentous complex (especially if the patient is not able to bear weight), and 3-D volumetric acquisitions have proven superiority over orthogonal proton density fat-suppressed imaging [33,38,41-45]. There is a high correlation between MRI and intraoperative findings for an unstable Lisfranc injury [44]. In the patient with a suspected Lisfranc injury and normal radiographs, the literature supports further advanced imaging by MRI and CT [21,33,43,46].

Turf Toe and Plantar Plate Injuries

MRI is the preferred imaging method for evaluating suspected “turf toe” and lesser metatarsal plantar plate injury by directly evaluating the soft-tissue structures of the capsuloligamentous complex as well as assessing chondral and osteochondral lesions [29,55,56].

Acute Tendinous Rupture

MRI tends to be used as a screening tool when one is not certain of the specific tendon injury or if concomitant osseous injury is suspected. Both MRI and US have been shown to be sensitive for the diagnosis of acute tendon rupture or dislocation in the foot [39]. In a surgically confirmed study, MRI was shown to have 83% sensitivity for diagnosing tendon and ligament traumatic injuries about the foot and ankle [37].

US Foot

The importance of focused US examinations is emphasized in the literature [57,58]. Protocol-based US evaluation identified 97.4% of symptomatic abnormalities in the distal extremities (including the foot), with additional accuracy obtained with focused examination [57].

Lisfranc Injury

Although the literature evidence is limited, US may hold promise as an alternative method to accurately evaluate for a significant Lisfranc injury providing direct and indirect assessment of the Lisfranc ligamentous complex as well as dynamic evaluation with weightbearing as demonstrated in a series of 10 patients [59]. Dorsal component of Lisfranc ligament is amenable to direct US evaluation [59,60], although this structure may not be critical for stability for the Lisfranc joint [20,32]. The physiologic deformation of the dorsal Lisfranc ligament resulting from functional loading emphasized the need for normative US data as well as proper positioning when bilateral evaluation is performed [61,62].

Turf Toe and Plantar Plate Injuries

US in the sagittal plane best visualizes the plantar plate between the flexor tendon and hyaline cartilage of the metatarsal head [63]. US has shown a 96% sensitivity compared with 87% sensitivity for MRI for the detection of lesser toe plantar plate tears; however, both modalities have poor specificity [64].

Acute Tendinous Rupture

Both MRI and US have been shown to be sensitive for the diagnosis of acute tendon rupture or dislocation in the foot [39]. US has also been reported to have a high sensitivity for peroneal tendon tears [65].

Variant 6: Adult or child older than 5 years of age. Acute trauma to the foot. Suspect penetrating trauma with a foreign body. Radiographs of the foot are negative. Next imaging study.

CT Foot

An experimental study for detection of a variety of foreign bodies (eg, fresh wood, dry wood, glass, porcelain, and plastic fragments) reported 63% sensitivity and 98% specificity for CT for detecting a foreign body [66]. CT was superior to MRI in identifying water-rich fresh wood.

MRI Foot

An experimental study reported 58% sensitivity and 100% specificity for MRI for detecting a foreign body [66]. In a clinical study including 8 patients with wooden foreign bodies, MRI showed the surrounding inflammatory response in all patients [28].

US Foot

Both radiographs and US are useful imaging tools to exclude a foreign body in the setting of penetrating trauma to the foot [24]. US is the imaging modality of choice if the foreign body is not radiopaque (eg, wood or plastic),

with a reported 90% sensitivity for visualizing wooden foreign bodies in some clinical and experimental studies [27,28]. US can be used effectively to locate wooden foreign bodies as small as 2.5 mm in length [27]. However, some experimental studies utilizing soft-tissue phantom models report lower overall sensitivity (<50%) for US for detection of foreign bodies [25]. US can identify a foreign body and can also help localize it and determine if it involves a tendon or a muscle and to evaluate for an abscess.

Summary of Recommendations

- **Variation 1:** Imaging is not recommended for the initial imaging of an adult or child older than 5 years of age with acute trauma to the foot when Ottawa rules can be evaluated without exclusionary criteria and are negative and there are no suspected abnormalities in regions not evaluated by the Ottawa rules.
- **Variation 2:** Radiographs of the foot, or when a patient is able to tolerate, radiographs with weightbearing of the foot are usually appropriate for the initial imaging of an adult or child older than 5 years of age with acute trauma to the foot when Ottawa rules can be evaluated without exclusionary criteria and are positive. These procedures are complementary (ie, more than one procedure is ordered as a set or simultaneously in which each procedure provides unique clinical information to effectively manage the patient's care).
- **Variation 3:** Radiographs of the foot are usually appropriate for the initial imaging of an adult or child older than 5 years of age with acute trauma to the foot when Ottawa rules cannot be ruled out due to exclusionary criteria. CT of the foot without IV contrast may be appropriate initial imaging study in high energy polytrauma patients.
- **Variation 4:** Radiographs of the foot and radiographs with weightbearing of the foot are usually appropriate for the initial imaging of an adult or child older than 5 years of age with acute trauma to the foot when Ottawa rules can be evaluated without exclusionary criteria and are negative or suspected pathology in an anatomic area not addressed by the Ottawa rules. These procedures are complementary (ie, more than one procedure is ordered as a set or simultaneously in which each procedure provides unique clinical information to effectively manage the patient's care). The panel did not agree on recommending CT of the foot without IV contrast for the initial imaging of patients in this clinical scenario. There is insufficient medical literature to conclude whether or not these patients would benefit from CT of the foot without IV contrast. CT of the foot without IV contrast in this patient population is controversial but can be appropriate.
- **Variation 5:** CT of the foot without IV contrast or MRI of the foot without IV contrast is usually appropriate for the next imaging study when radiographs are normal or equivocal of an adult or child older than 5 years of age with acute trauma to the foot and suspected Lisfranc injury, tendon injury, or occult fracture or dislocation. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care). US of the foot can be the appropriate next imaging study when radiographs are normal or equivocal of an adult or child older than 5 years of age with acute trauma to the foot as a focused examination in selected clinical scenarios, such as suspected plantar plate injuries or acute tendinous rupture.
- **Variation 6:** US of the foot is usually appropriate for the next imaging study when radiographs are negative for an adult or child older than 5 years of age with acute trauma to the foot and suspected penetrating trauma with a foreign body.

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at <https://acsearch.acr.org/list>. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document [67].

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	0 mSv	0 mSv
⊕	<0.1 mSv	<0.03 mSv
⊕⊕	0.1-1 mSv	0.03-0.3 mSv
⊕⊕⊕	1-10 mSv	0.3-3 mSv
⊕⊕⊕⊕	10-30 mSv	3-10 mSv
⊕⊕⊕⊕⊕	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

References

1. Bachmann LM, Kolb E, Koller MT, Steurer J, ter Riet G. Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review. *BMJ* 2003;326:417.

2. Dowling S, Spooner CH, Liang Y, et al. Accuracy of Ottawa Ankle Rules to exclude fractures of the ankle and midfoot in children: a meta-analysis. *Acad Emerg Med* 2009;16:277-87.
3. Dayan PS, Vitale M, Langsam DJ, et al. Derivation of clinical prediction rules to identify children with fractures after twisting injuries of the ankle. *Acad Emerg Med* 2004;11:736-43.
4. Smith KR, Brown CK, Brewer KL. Can clinical prediction rules used in acute pediatric ankle and midfoot injuries be applied to an adult population? *Am J Emerg Med* 2011;29:441-5.
5. McLaughlin SA, Binder DS, Sklar DP. Ottawa ankle rules and the diabetic foot. *Ann Emerg Med* 1998;32:518.
6. Stiell IG, Greenberg GH, McKnight RD, et al. Decision rules for the use of radiography in acute ankle injuries. Refinement and prospective validation. *JAMA* 1993;269:1127-32.
7. Bancroft LW, Kransdorf MJ, Adler R, et al. ACR Appropriateness Criteria Acute Trauma to the Foot. *J Am Coll Radiol* 2015;12:575-81.
8. De Smet AA, Doherty MP, Norris MA, Hollister MC, Smith DL. Are oblique views needed for trauma radiography of the distal extremities? *AJR Am J Roentgenol* 1999;172:1561-5.
9. Broomhead A, Stuart P. Validation of the Ottawa Ankle Rules in Australia. *Emerg Med (Fremantle)* 2003;15:126-32.
10. Leisey J. Prospective validation of the Ottawa Ankle Rules in a deployed military population. *Mil Med* 2004;169:804-6.
11. Hatch RL, Hacking S. Evaluation and management of toe fractures. *Am Fam Physician* 2003;68:2413-8.
12. Schnaue-Constantouris EM, Birrer RB, Grisafi PJ, Dellacorte MP. Digital foot trauma: emergency diagnosis and treatment. *J Emerg Med* 2002;22:163-70.
13. Canagasabey MD, Callaghan MJ, Carley S. The sonographic Ottawa Foot and Ankle Rules study (the SOFAR study). *Emerg Med J* 2011;28:838-40.
14. Sconfienza LM, Albano D, Allen G, et al. Clinical indications for musculoskeletal ultrasound updated in 2017 by European Society of Musculoskeletal Radiology (ESSR) consensus. *Eur Radiol* 2018;28:5338-51.
15. Zhang T, Chen W, Su Y, Wang H, Zhang Y. Does axial view still play an important role in dealing with calcaneal fractures? *BMC Surg* 2015;15:19.
16. Rankine JJ, Nicholas CM, Wells G, Barron DA. The diagnostic accuracy of radiographs in Lisfranc injury and the potential value of a craniocaudal projection. *AJR Am J Roentgenol* 2012;198:W365-9.
17. Shapiro MS, Wascher DC, Finerman GA. Rupture of Lisfranc's ligament in athletes. *Am J Sports Med* 1994;22:687-91.
18. Kalia V, Fishman EK, Carrino JA, Fayad LM. Epidemiology, imaging, and treatment of Lisfranc fracture-dislocations revisited. *Skeletal Radiol* 2012;41:129-36.
19. Nunley JA, Vertullo CJ. Classification, investigation, and management of midfoot sprains: Lisfranc injuries in the athlete. *Am J Sports Med* 2002;30:871-8.
20. Siddiqui NA, Galizia MS, Almusa E, Omar IM. Evaluation of the tarsometatarsal joint using conventional radiography, CT, and MR imaging. *Radiographics* 2014;34:514-31.
21. Haapamaki VV, Kiuru MJ, Koskinen SK. Ankle and foot injuries: analysis of MDCT findings. *AJR Am J Roentgenol* 2004;183:615-22.
22. Watura R, Cobby M, Taylor J. Multislice CT in imaging of trauma of the spine, pelvis and complex foot injuries. *Br J Radiol* 2004;77 Spec No 1:S46-63.
23. Atila OD, Yesilaras M, Kilic TY, et al. The accuracy of bedside ultrasonography as a diagnostic tool for fractures in the ankle and foot. *Acad Emerg Med* 2014;21:1058-61.
24. Friedman DI, Forti RJ, Wall SP, Crain EF. The utility of bedside ultrasound and patient perception in detecting soft tissue foreign bodies in children. *Pediatr Emerg Care* 2005;21:487-92.
25. Manthey DE, Storrow AB, Milbourn JM, Wagner BJ. Ultrasound versus radiography in the detection of soft-tissue foreign bodies. *Ann Emerg Med* 1996;28:7-9.
26. Pugmire BS, Shailam R, Sagar P, et al. Initial Clinical Experience With Extremity Cone-Beam CT of the Foot and Ankle in Pediatric Patients. *AJR Am J Roentgenol* 2016;206:431-5.
27. Jacobson JA, Powell A, Craig JG, Bouffard JA, van Holsbeeck MT. Wooden foreign bodies in soft tissue: detection at US. *Radiology* 1998;206:45-8.
28. Peterson JJ, Bancroft LW, Kransdorf MJ. Wooden foreign bodies: imaging appearance. *AJR Am J Roentgenol* 2002;178:557-62.
29. McCormick JJ, Anderson RB. Turf toe: anatomy, diagnosis, and treatment. *Sports Health* 2010;2:487-94.

30. Klein EE, Weil L, Jr., Weil LS, Sr., Knight J. The underlying osseous deformity in plantar plate tears: a radiographic analysis. *Foot Ankle Spec* 2013;6:108-18.
31. Klein EE, Weil L, Jr., Weil LS, Sr., Bowen M, Fleischer AE. Positive drawer test combined with radiographic deviation of the third metatarsophalangeal joint suggests high grade tear of the second metatarsophalangeal joint plantar plate. *Foot Ankle Spec* 2014;7:466-70.
32. Linklater JM. Imaging of sports injuries in the foot. *AJR Am J Roentgenol* 2012;199:500-8.
33. Preidler KW, Peicha G, Lajtai G, et al. Conventional radiography, CT, and MR imaging in patients with hyperflexion injuries of the foot: diagnostic accuracy in the detection of bony and ligamentous changes. *AJR Am J Roentgenol* 1999;173:1673-7.
34. Freund W, Weber F, Billich C, Schuetz UH. The foot in multistage ultra-marathon runners: experience in a cohort study of 22 participants of the Trans Europe Footrace Project with mobile MRI. *BMJ Open* 2012;2.
35. Sormaala MJ, Ruohola JP, Mattila VM, Koskinen SK, Pihlajamaki HK. Comparison of 1.5T and 3T MRI scanners in evaluation of acute bone stress in the foot. *BMC Musculoskelet Disord* 2011;12:128.
36. Gerling MC, Pfirrmann CW, Farooki S, et al. Posterior tibialis tendon tears: comparison of the diagnostic efficacy of magnetic resonance imaging and ultrasonography for the detection of surgically created longitudinal tears in cadavers. *Invest Radiol* 2003;38:51-6.
37. Kuwada GT. Surgical correlation of preoperative MRI findings of trauma to tendons and ligaments of the foot and ankle. *J Am Podiatr Med Assoc* 2008;98:370-3.
38. Macmahon PJ, Dheer S, Raikin SM, et al. MRI of injuries to the first interosseous cuneometatarsal (Lisfranc) ligament. *Skeletal Radiol* 2009;38:255-60.
39. Klauser AS, Tagliafico A, Allen GM, et al. Clinical indications for musculoskeletal ultrasound: a Delphi-based consensus paper of the European Society of Musculoskeletal Radiology. *Eur Radiol* 2012;22:1140-8.
40. Nallamshetty L, Nazarian LN, Schweitzer ME, et al. Evaluation of posterior tibial pathology: comparison of sonography and MR imaging. *Skeletal Radiol* 2005;34:375-80.
41. Castro M, Melao L, Canella C, et al. Lisfranc joint ligamentous complex: MRI with anatomic correlation in cadavers. *AJR Am J Roentgenol* 2010;195:W447-55.
42. Melao L, Canella C, Weber M, Negrao P, Trudell D, Resnick D. Ligaments of the transverse tarsal joint complex: MRI-anatomic correlation in cadavers. *AJR Am J Roentgenol* 2009;193:662-71.
43. Potter HG, Deland JT, Gusmer PB, Carson E, Warren RF. Magnetic resonance imaging of the Lisfranc ligament of the foot. *Foot Ankle Int* 1998;19:438-46.
44. Raikin SM, Elias I, Dheer S, Besser MP, Morrison WB, Zoga AC. Prediction of midfoot instability in the subtle Lisfranc injury. Comparison of magnetic resonance imaging with intraoperative findings. *J Bone Joint Surg Am* 2009;91:892-9.
45. Ulbrich EJ, Zubler V, Sutter R, Espinosa N, Pfirrmann CW, Zanetti M. Ligaments of the Lisfranc joint in MRI: 3D-SPACE (sampling perfection with application optimized contrasts using different flip-angle evolution) sequence compared to three orthogonal proton-density fat-saturated (PD fs) sequences. *Skeletal Radiol* 2013;42:399-409.
46. Ting AY, Morrison WB, Kavanagh EC. MR imaging of midfoot injury. *Magn Reson Imaging Clin N Am* 2008;16:105-15, vi.
47. Ballard DH, Campbell KJ, Blanton LE, et al. Tendon entrapments and dislocations in ankle and hindfoot fractures: evaluation with multidetector computed tomography. *Emerg Radiol* 2016;23:357-63.
48. Golshani A, Zhu L, Cai C, Beckmann NM. Incidence and Association of CT Findings of Ankle Tendon Injuries in Patients Presenting With Ankle and Hindfoot Fractures. *AJR Am J Roentgenol* 2017;208:373-79.
49. Ohashi K, Restrepo JM, El-Khoury GY, Berbaum KS. Peroneal tendon subluxation and dislocation: detection on volume-rendered images--initial experience. *Radiology* 2007;242:252-7.
50. Rosenfeld P. Acute and chronic peroneal tendon dislocations. *Foot Ankle Clin* 2007;12:643-57, vii.
51. Baker JC, Hoover EG, Hillen TJ, Smith MV, Wright RW, Rubin DA. Subradiographic Foot and Ankle Fractures and Bone Contusions Detected by MRI in Elite Ice Hockey Players. *Am J Sports Med* 2016;44:1317-23.
52. Walter WR, Hirschmann A, Alaia EF, Garwood ER, Rosenberg ZS. JOURNAL CLUB: MRI Evaluation of Midtarsal (Chopart) Sprain in the Setting of Acute Ankle Injury. *AJR Am J Roentgenol* 2018;210:386-95.
53. Hirschmann A, Walter WR, Alaia EF, Garwood E, Amsler F, Rosenberg ZS. Acute Fracture of the Anterior Process of Calcaneus: Does It Herald a More Advanced Injury to Chopart Joint? *AJR Am J Roentgenol* 2018;210:1123-30.

54. Torriani M, Thomas BJ, Bredella MA, Ouellette H. MRI of metatarsal head subchondral fractures in patients with forefoot pain. *AJR Am J Roentgenol* 2008;190:570-5.
55. Arbona N, Jedrzynski M, Frankfather R, et al. Is glass visible on plain radiographs? A cadaver study. *J Foot Ankle Surg* 1999;38:264-70.
56. Nery C, Umans H, Baumfeld D. Etiology, Clinical Assessment, and Surgical Repair of Plantar Plate Tears. *Semin Musculoskelet Radiol* 2016;20:205-13.
57. Jamadar DA, Jacobson JA, Caoili EM, et al. Musculoskeletal sonography technique: focused versus comprehensive evaluation. *AJR Am J Roentgenol* 2008;190:5-9.
58. Slater HK. Acute peroneal tendon tears. *Foot Ankle Clin* 2007;12:659-74, vii.
59. Woodward S, Jacobson JA, Femino JE, Morag Y, Fessell DP, Dong Q. Sonographic evaluation of Lisfranc ligament injuries. *J Ultrasound Med* 2009;28:351-7.
60. Kaicker J, Zajac M, Shergill R, Choudur HN. Ultrasound appearance of the normal Lisfranc ligament. *Emerg Radiol* 2016;23:609-14.
61. Marshall JJ, Graves NC, Rettedal DD, Frush K, Vardaxis V. Ultrasound assessment of bilateral symmetry in dorsal Lisfranc ligament. *J Foot Ankle Surg* 2013;52:319-23.
62. Ryba D, Ibrahim N, Choi J, Vardaxis V. Evaluation of dorsal Lisfranc ligament deformation with load using ultrasound imaging. *Foot (Edinb)* 2016;26:30-5.
63. Khoury V, Guillin R, Dhanju J, Cardinal E. Ultrasound of ankle and foot: overuse and sports injuries. *Semin Musculoskelet Radiol* 2007;11:149-61.
64. Gregg J, Silberstein M, Schneider T, Marks P. Sonographic and MRI evaluation of the plantar plate: A prospective study. *Eur Radiol* 2006;16:2661-9.
65. Grant TH, Kelikian AS, Jereb SE, McCarthy RJ. Ultrasound diagnosis of peroneal tendon tears. A surgical correlation. *J Bone Joint Surg Am* 2005;87:1788-94.
66. Pattampaspong N, Srisuwan T, Sivasomboon C, et al. Accuracy of radiography, computed tomography and magnetic resonance imaging in diagnosing foreign bodies in the foot. *Radiol Med* 2013;118:303-10.
67. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: <https://www.acr.org/-/media/ACR/Files/Appropriateness-Criteria/RadiationDoseAssessmentIntro.pdf>. Accessed September 30, 2019.

The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.