American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Acute Trauma to the Foot**

Variant 1: **Adult or child >5 years old. Acute injury to the foot; positive Ottawa Rules, suspicious for fracture. First study.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray foot	9		☢
CT foot without IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot without and with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
MRI foot without IV contrast	1		O
MRI foot without and with IV contrast	1		O
US foot	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 2: **Adult or child >5 years old. Acute injury to the foot; does not meet the Ottawa Rules; no focal tenderness in the foot or palpable abnormality of the foot on physical examination; able to walk; neurologically intact (including no peripheral neuropathy). First study.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray foot	1		☢
CT foot without IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot without and with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
MRI foot without IV contrast	1		O
MRI foot without and with IV contrast	1		O
US foot	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 3: **Adult or child >5 years old. Acute injury to the foot; does not meet the Ottawa Rules; patient is not neurologically intact and/or has a peripheral neuropathy that involves the feet. First study.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray foot	9		☢
CT foot without IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot without and with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
MRI foot without IV contrast	1		O
MRI foot without and with IV contrast	1		O
US foot	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: **Acute Trauma to the Foot**

Variant 4: **Adult or child >5 years old. Acute injury to the foot; does not meet the Ottawa Rules; patient has polytrauma. First study.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray foot	9		☢
CT foot without IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot without and with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
MRI foot without IV contrast	1		O
MRI foot without and with IV contrast	1		O
US foot	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 5: **Adult or child >5 years old. Acute injury to the foot; does not meet the Ottawa Rules; physical examination is concerning for a Lisfranc injury. First study.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray foot	9		☢
X-ray foot with weight bearing	7		☢
CT foot without IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot without and with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
MRI foot without IV contrast	1		O
MRI foot without and with IV contrast	1		O
US foot	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 6: **Adult or child >5 years old. Acute injury to the foot; physical examination is concerning for a Lisfranc injury. Radiographs are normal and patient is not able to tolerate a weight-bearing radiographic view. Next imaging study.**

Radiologic Procedure	Rating	Comments	RRL*
MRI foot without IV contrast	9	MRI and CT are alternative examinations. Only one should be performed. MRI is preferred.	O
CT foot without IV contrast	9	MRI and CT are alternative examinations. Only one should be performed. MRI is preferred. The RRL for the adult procedure is ☢ .	☢ ☢
CT foot with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot without and with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
MRI foot without and with IV contrast	1		O
US foot	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: **Acute Trauma to the Foot**

Variant 7: **Adult or child >5 years old. Acute injury to the foot; physical examination is concerning for an acute tendinous rupture or dislocation in the foot; radiographs are negative. Next imaging study.**

Radiologic Procedure	Rating	Comments	RRL*
MRI foot without IV contrast	9		O
CT foot without IV contrast	5	The RRL for the adult procedure is ☢ .	☢ ☢
US foot	5		O
CT foot without and with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
MRI foot without and with IV contrast	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Variant 8: **Adult or child >5 years old. Metatarsal-phalangeal joint injury. Suspect plantar plate injury. First study.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray foot	9		☢
X-ray foot forced dorsiflexion lateral	5		☢
Fluoroscopy foot	5		☢
MRI foot without IV contrast	5		O
CT foot without IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot without and with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
MRI foot without and with IV contrast	1		O
US foot	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Variant 9: **Adult or child >5 years old. Acute injury to the foot; physical examination is concerning for penetrating trauma with a foreign body in the soft tissues. First study.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray foot	9		☢
US foot	7	Consider this procedure if the foreign body is known to be not radiopaque.	O
CT foot without IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot without and with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
MRI foot without IV contrast	1		O
MRI foot without and with IV contrast	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Clinical Condition: **Acute Trauma to the Foot**

Variant 10: **Adult or child >5 years old. Acute injury to the foot; physical examination is concerning for penetrating trauma with a foreign body in the soft tissues. Radiographs of the foot are negative. Next best study.**

Radiologic Procedure	Rating	Comments	RRL*
US foot	9		O
CT foot without IV contrast	5	The RRL for the adult procedure is ☢ .	☢ ☢
MRI foot without IV contrast	5		O
CT foot with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT foot without and with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
MRI foot without and with IV contrast	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

ACUTE TRAUMA TO THE FOOT

Expert Panel on Musculoskeletal Imaging: Laura W. Bancroft, MD[1]; Mark J. Kransdorf, MD[2]; Ronald Adler, MD, PhD[3]; Marc Appel, MD[4]; Francesca D. Beaman, MD[5]; Stephanie A. Bernard, MD[6]; Michael A. Bruno, MD[7]; Molly E. Dempsey, MD[8]; Ian Blair Fries, MD[9]; Viviane Khoury, MD[10]; Bharti Khurana, MD[11]; Timothy J. Mosher, MD[12]; Catherine C. Roberts, MD[13]; Michael J. Tuite, MD[14]; Robert J. Ward, MD[15]; Adam C. Zoga, MD[16]; Barbara N. Weissman, MD.[17]

Summary of Literature Review

Introduction/Background

In the setting of acute trauma to the foot, the clinical indications for medical imaging (known as the Ottawa Rules) have been 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.

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]. However, multiple conditions or scenarios preclude the use of the Ottawa Rules for determining if medical imaging is necessary [2,3]. 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, greater than 10 days after trauma, a return visit for continued traumatic foot pain, the setting of polytrauma, altered sensorium, neurologic abnormality affecting the foot, or underlying bone disease. The Ottawa Rules for the ankle and midfoot have been shown to be effective for the pediatric population (greater than 5 years of age) [4]. 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 [5,6].

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. There is little in the literature on medical decision-making of when to order a radiographic study of the toes. In general, if a fracture of a toe is suspected, radiographs can document or rule out a fracture [7,8]. If radiographs are negative, magnetic resonance imaging (MRI) may be obtained in select patients with forefoot pain due to its increased sensitivity for the early detection of metatarsal head subchondral fracture [9]. Both radiographs and ultrasound (US) are useful medical imaging tools to exclude a foreign body in the setting of penetrating trauma to the foot [10].

Overview of Imaging Modalities

Radiographs are the mainstay of initial medical 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 [11]. Computed tomography (CT) is commonly used in evaluating the true extent of osseous injury in complex fractures and at times is used as the initial medical imaging study in polytrauma patients and in complex regions such as the midfoot [12-14]. In the polytrauma patient, approximately 25% of foot fractures identified on CT are overlooked on radiographs [12]. Therefore, CT is essential for appropriate treatment planning and determining the true extent of osseous injuries in the polytrauma patient.

[1]Principal Author, Radiology Specialists of Florida, Maitland, Florida. [2]Panel Vice-chair, Mayo Clinic, Phoenix, Arizona. [3]NYU Center for Musculoskeletal Care, New York, New York. [4]Warwick Valley Orthopedic Surgery, Warwick, New York, American Academy of Orthopaedic Surgeons. [5]Univeristy of Kentucky, Lexington, Kentucky. [6]Penn State Milton S. Hershey Medical Center, Hershey, Pennsylvania. [7]Penn State Milton S. Hershey Medical Center, Hershey, Pennsylvania. [8]Texas Scottish Rite Hospital, Dallas, Texas. [9]Bone, Spine and Hand Surgery, Chartered, Brick, NJ, American Academy of Orthopaedic Surgeons. [10]Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania. [11]Brigham & Women's Hospital, Boston, Massachusetts. [12]Penn State Milton S. Hershey Medical Center, Hershey, Pennsylvania. [13]Mayo Clinic, Phoenix, Arizona. [14]University of Wisconsin Hospital, Madison, Wisconsin. [15]Tufts Medical Center, Boston, Massachusetts. [16]Thomas Jefferson University, Philadelphia, Pennsylvania. [17]Panel Chair, Brigham & Women's Hospital, Boston, Massachusetts.

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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 [15-18]. The choice of modality is usually determined by costs, availability of technology, and availability of expert musculoskeletal sonographers and interpreters. MRI is also the most sensitive modality for the detection of occult fracture and acute bone stress changes [19,20].

Discussion of Imaging Modalities by Variant

Variant 1: Adult or child >5 years old. Acute injury to the foot; positive Ottawa Rules, suspicious for fracture. First study.

Variant 2: Adult or child >5 years old. Acute injury to the foot; does not meet the Ottawa Rules; no focal tenderness in the foot or palpable abnormality of the foot on physical examination; able to walk; neurologically intact (including no peripheral neuropathy). First study.

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 of them in determining the presence of a foot fracture [1,21,22]. The more serious potential problems in determining the need for imaging occur in the patient who does not meet the inclusion criteria for medical imaging by the Ottawa Rules of the foot. These criteria are stated in the introduction [2,3]. One should carefully evaluate the patient to make sure they do not meet any of the exclusionary criteria before implementing the Ottawa Rules. A preliminary sonographic study has had less successful results compared to radiographic evaluation, with 90.9% sensitivity and specificity [23].

Variant 3: Adult or child >5 years old. Acute injury to the foot; does not meet the Ottawa Rules; patient is not neurologically intact and/or has a peripheral neuropathy that involves the feet. First study.

In diabetics or other patients with a neuropathy that affects the feet, the traumatized foot should be radiographed. The Ottawa rules should not be applied in this clinical setting, since 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 [2]. As well, it is not clinically possible to utilize the Ottawa Rules when the patient is neurologically compromised. If a foot fracture is suspected in a neurologically compromised patient, the foot should be imaged.

Variant 4: Adult or child >5 years old. Acute injury to the foot; does not meet the Ottawa Rules; patient has polytrauma. First study.

General practice is to radiograph the foot; however, data can support using CT as the initial imaging modality in polytrauma patients, including those patients who are neurologically compromised [12,14]. In one study of polytrauma patients, 25% of foot fractures demonstrated on CT were not detectable on radiographs [12].

Variant 5: Adult or child >5 years old. Acute injury to the foot; does not meet the Ottawa Rules; physical examination is concerning for a Lisfranc injury. First study.

Variant 6: Adult or child >5 years old. Acute injury to the foot; physical examination is concerning for a Lisfranc injury. Radiographs are normal and patient is not able to tolerate a weight-bearing radiographic view. Next imaging study.

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 (AP, oblique, and lateral), a weight-bearing AP view or AP view with 20° craniocaudal angulation can be added [24,25]. Weight-bearing views have been shown to increase the abnormal alignment at the first intermetatarsal space, thus making it easier to identify a Lisfranc injury [24]. There is also debate as to whether radiography should be the initial imaging modality in the setting of a suspected Lisfranc injury, since patients with Lisfranc sprains may incur ligamentous damage without diastasis [26]. CT and MRI have been advocated as the best imaging tests (especially if the patient is not able to bear weight), and 3D-volumetric acquisitions have proven superiority over orthogonal proton density fat-suppressed imaging [17,18,27-31]. Recently, it has been shown that there is a high correlation between MRI and intraoperative findings for an unstable Lisfranc injury [18]. CT is also useful in demonstrating the multiple metatarsal and cuneiform fractures that can be associated with a ligamentous Lisfranc injury [12,14,30]. In the patient with a suspected Lisfranc injury and normal radiographs, the literature supports further advanced imaging by MRI and CT [12,29,30,32]. Finally, US may hold promise as another method to accurately evaluate for a significant Lisfranc injury; however, further studies will need to be done to confirm this [33].

Variant 7: Adult or child >5 years old. Acute injury to the foot; physical examination is concerning for an acute tendinous rupture or dislocation in the foot; radiographs are negative. Next imaging study.

Both MRI and US have been shown to be sensitive for the diagnosis of acute tendon rupture or dislocation in the foot [34]. In a surgically confirmed study, MRI was shown to have 83% sensitivity for diagnosing tendon and ligament traumatic injuries about the foot and ankle [16]. Both MRI and US have been shown to have similar sensitivities for tendon injuries about the foot and ankle, specifically the tibialis posterior tendon [15,35]. US has also been reported to have a high sensitivity for peroneal tendon tears [36]. One has to weigh several factors when deciding between MRI and US for evaluating acute soft-tissue injury of the foot, including cost and availability of health-care providers who are adept at performing and/or interpreting musculoskeletal US [37]. Protocol-based sonographic evaluation identified 97.4% of symptomatic abnormalities in the distal extremities (including the foot), with additional accuracy obtained with focused examination [38]. 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. Finally, CT is typically used for preoperative planning for fracture treatment and evaluation. However, volume-rendered CT imaging has been shown to be a quick and effective way of documenting peroneal tendon dislocations, which are associated with comminuted calcaneal fractures [39,40].

Variant 8: Adult or child >5 years old. Metatarsal-phalangeal joint injury. Suspect plantar plate injury. First study.

The best initial imaging study for evaluating hallux plantar plate disruption after metatarsal-phalangeal (MTP) joint injury is weight-bearing AP, lateral, and sesamoid axial views [41]. Patients with plantar plate rupture will have proximal migration of one or both hallux sesamoids. The sesamoids will not track distally with great toe extension at the MTP joint on forced dorsiflexion lateral view or fluoroscopy [41]. US in the sagittal plane best visualizes the plantar plate between the flexor tendon and hyaline cartilage of the metatarsal head [42]. Tears may be partial or complete and mainly involve the second toe, and less commonly the third and fourth toes [42]. US has shown a 96% sensitivity compared with 87% sensitivity of MRI for the detection of lesser toe plantar plate tears, however both modalities have poor specificity [43]. MRI is the preferred imaging method for evaluating suspected “turf toe,” by directly evaluating the soft-tissue structures of the capsuloligamentous complex as well as assessing chondral and osteochondral lesions [41,44].

Variant 9: Adult or child >5 years old. Acute injury to the foot; physical examination is concerning for penetrating trauma with a foreign body in the soft tissues. First study.

Variant 10: Adult or child >5 years old. Acute injury to the foot; physical examination is concerning for penetrating trauma with a foreign body in the soft tissues. Radiographs of the foot are negative. Next best study.

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, glass, or metal) [45]. Radiographic evaluation for a radiopaque foreign body has an approximately 98% sensitivity [46]. 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. 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 [47,48]. One study reported an overall sensitivity and specificity for detection of a variety of foreign bodies (eg, fresh wood, dry wood, glass, porcelain, and plastic fragments) of 29% and 100% with radiographs, 63% and 98% with CT, and 58% and 100% with MRI [49].

Summary of Recommendations

- If a patient with acute foot trauma fits the inclusion criteria for the Ottawa Rules and meets the Ottawa Rules’ criteria for imaging, the first imaging study should be a 3-view radiographic series of the foot.
- If a patient with acute foot trauma does not meet the inclusion criteria to be evaluated by the Ottawa Rules (such as a diabetic with peripheral neuropathy involving the foot), then imaging should be obtained. The first imaging study in this scenario should be a 3-view radiographic series of the foot.
- If there is clinical concern for midfoot injury (such as a Lisfranc injury), then imaging should be performed. The first imaging study in this situation is usually a 3-view radiographic series of the foot with weight bearing on at least the AP view, if possible. If there is continued clinical concern for a Lisfranc injury in the setting of a normal radiograph, then advanced imaging (MRI or CT) should be considered and performed on a case-by-case basis. Likewise, when there is a clinical concern for an acute tendon rupture, further imaging with MRI or US would be confirmatory.

- If there is clinical suspicion for plantar plate injury after MTP joint injury, radiography is the initial imaging modality. Weight-bearing AP, lateral, and sesamoid axial views may detect proximal migration of one or both hallux sesamoids with great toe injuries. US and MRI can directly evaluate the soft-tissue structures of the capsuloligamentous complex, specifically the plantar plate.
- In the setting of penetrating trauma to the foot with a possible foreign body, radiography (if the foreign body is radiopaque) or US (with nonradiopaque foreign bodies) should be used to determine if a foreign body is indeed present.

Summary of Evidence

Of the 50 references cited in the *ACR Appropriateness Criteria® Acute Trauma to the Foot* document, all of them are categorized as diagnostic references including 2 well-designed studies, 9 good quality studies, and 16 quality studies that may have design limitations. There are 23 references that may not be useful as primary evidence.

The 50 references cited in the *ACR Appropriateness Criteria® Acute Trauma to the Foot* document were published between 1993–2013.

While there are references that report on studies with design limitations, 11 well-designed or good quality studies provide good evidence.

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, both because of 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 to 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.

Relative Radiation Level Designations		
Relative Radiation Level*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
O	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".		

Supporting Documents

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

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