American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Acute Hand and Wrist Trauma**

Variant 1: **Wrist trauma, first examination.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray wrist	9		☢
CT wrist without IV contrast	1		☢
CT wrist with IV contrast	1		☢
CT wrist without and with IV contrast	1		☢
MRI wrist without IV contrast	1		O
MRI wrist without and with IV contrast	1		O
Tc-99m bone scan wrist	1		☢☢☢
US wrist	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: **Suspect acute distal radius fracture. Radiographs normal. Next procedure.**

Radiologic Procedure	Rating	Comments	RRL*
Cast and repeat x-ray wrist in 10-14 days	8		☢
MRI wrist without IV contrast	8		O
CT wrist without IV contrast	7		☢
MRI wrist without and with IV contrast	1		O
CT wrist with IV contrast	1		☢
CT wrist without and with IV contrast	1		☢
Tc-99m bone scan wrist	1		☢☢☢
US wrist	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 Hand and Wrist Trauma**

Variant 3: **Comminuted, intra-articular distal radius fracture on radiographs. Surgical planning.**

Radiologic Procedure	Rating	Comments	RRL*
CT wrist without IV contrast	9	This procedure is especially useful if 3-D reconstruction is available.	☢
MRI wrist without IV contrast	5	This procedure may be helpful to diagnose for ligament or soft-tissue injuries.	O
CT wrist with IV contrast	1		☢
CT wrist without and with IV contrast	1		☢
MRI wrist without and with IV contrast	1		O
Tc-99m bone scan wrist	1		☢☢☢
US wrist	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 4: **Suspect acute scaphoid fracture, first examination.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray wrist	9		☢
CT wrist without IV contrast	1		☢
CT wrist with IV contrast	1		☢
CT wrist without and with IV contrast	1		☢
MRI wrist without IV contrast	1		O
MRI wrist without and with IV contrast	1		O
Tc-99m bone scan wrist	1		☢☢☢
US wrist	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 Hand and Wrist Trauma**

Variant 5: **Suspect acute scaphoid fracture. Radiographs normal. Next procedure.**

Radiologic Procedure	Rating	Comments	RRL*
MRI wrist without IV contrast	9		O
Cast and repeat x-ray wrist in 10-14 days	8		☢
CT wrist without IV contrast	7		☢
Tc-99m bone scan wrist	3	This procedure may be useful with SPECT/CT.	☢☢☢
MRI wrist without and with IV contrast	1		O
CT wrist with IV contrast	1		☢
CT wrist without and with IV contrast	1		☢
US wrist	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: **Suspected occult scaphoid fracture. Initial radiographs and repeat radiographs after 10–14 days of casting are normal. Continued clinical suspicion of scaphoid fracture. Next procedure.**

Radiologic Procedure	Rating	Comments	RRL*
MRI wrist without IV contrast	9		O
CT wrist without IV contrast	8		☢
Tc-99m bone scan wrist	4	SPECT/CT greatly enhances the utility of this procedure.	☢☢☢
MRI wrist without and with IV contrast	1		O
CT wrist with IV contrast	1		☢
CT wrist without and with IV contrast	1		☢
US wrist	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 Hand and Wrist Trauma**

Variant 7: **Suspect distal radioulnar joint subluxation.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray wrist	9		☢
CT wrist without IV contrast bilateral	9	This procedure is especially useful if 3-D reconstruction is available. Bilateral wrist CT (pronated and supinated) is indicated.	☢
MRI wrist without IV contrast	5		O
CT wrist with IV contrast bilateral	1		☢
CT wrist without and with IV contrast bilateral	1		☢
MRI wrist without and with IV contrast	1		O
Tc-99m bone scan wrist	1		☢☢☢
US wrist	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: **Suspect hook of the hamate fracture. Initial radiographs normal or equivocal.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray wrist additional views	9	Additional views such as hamate or carpal tunnel are indicated when using this procedure.	☢
CT wrist without IV contrast	9		☢
MRI wrist without IV contrast	5		O
CT wrist with IV contrast	1		☢
CT wrist without and with IV contrast	1		☢
Tc-99m bone scan wrist	1		☢☢☢
MRI wrist without and with IV contrast	1		O
US wrist	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 Hand and Wrist Trauma**

Variant 9: **Suspect metacarpal fracture or dislocation.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray hand	9	Use this procedure for the initial study.	☢
CT hand without IV contrast	7	Use this procedure for surgical planning or if there is high suspicion and a negative radiograph.	☢
CT hand with IV contrast	1		☢
CT hand without and with IV contrast	1		☢
MRI hand without IV contrast	1		O
MRI hand without and with IV contrast	1		O
Tc-99m bone scan hand	1		☢☢☢
US hand	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 10: **Suspect phalangeal fracture or dislocation.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray finger	9		☢
CT finger without IV contrast	2		☢
CT finger with IV contrast	1		☢
CT finger without and with IV contrast	1		☢
Tc-99m bone scan hand	1		☢☢☢
MRI finger without IV contrast	1		O
MRI finger without and with IV contrast	1		O
US finger	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 Hand and Wrist Trauma**

Variant 11: **Suspect thumb fracture or dislocation.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray thumb	9	Consider this procedure for the initial study.	☢
CT thumb without IV contrast	5	Consider this procedure if radiographs negative and/or for surgical planning.	☢
MRI thumb without IV contrast	5	Consider this procedure if radiographs negative.	O
CT thumb with IV contrast	1		☢
CT thumb without and with IV contrast	1		☢
MRI thumb without and with IV contrast	1		O
Tc-99m bone scan hand	1		☢☢☢
US thumb	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 12: **Suspect gamekeeper injury (thumb metacarpophalangeal ulnar collateral ligament injury).**

Radiologic Procedure	Rating	Comments	RRL*
X-ray thumb	9		☢
MRI thumb without IV contrast	9		O
US thumb	8	Perform this procedure in specialized centers where the requisite level of expertise is available.	O
X-ray thumb with valgus stress and contralateral comparison	5	This procedure may be diagnostically appropriate but is a painful examination and puts the patient at risk for worsening injury. Recommend consultation with treating physician.	☢
MR arthrography thumb	2		O
MRI thumb without and with IV contrast	1		O
X-ray arthrography thumb	1		☢
CT thumb without IV contrast	1		☢
CT thumb with IV contrast	1		☢
CT thumb without and with IV contrast	1		☢
Tc-99m bone scan hand	1		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

ACUTE HAND AND WRIST TRAUMA

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Summary of Literature Review

Introduction/Background

The hand and wrist are, arguably, the most active and complex components of the upper extremity, and, as such, are highly vulnerable to injuries with significant long-term consequences if diagnosis is delayed or incorrect. Hand and wrist fractures and fracture-dislocations are more common than those of any other part of the body [1,2]. For most patients with trauma to the hand, wrist, or both, radiographs provide adequate diagnostic information and guidance for the treating physician. However, in one large study, wrist fractures, especially those of the distal radius and scaphoid, accounted for more delayed diagnoses than any other traumatized region in patients with initially normal emergency room radiographs [3]. Thus, when initial radiographs are negative, or in the presence of certain clinical or radiographic findings, further imaging is appropriate. This may be as simple as additional radiographic projections, or it may include sonography, bone scintigraphy, computed tomography (CT), or magnetic resonance imaging (MRI). Sonography, in particular, has played a small role in the evaluation of acute hand and wrist trauma in the past but is increasingly utilized in the evaluation of acute hand and wrist trauma in specialized centers and has been demonstrated in recent studies to discriminate fine ligamentous structures stabilizing the wrist joints [4]; however, such use requires a level of expertise that is not uniformly available. The use of sonography for the initial evaluation of acute hand and wrist injury and instability may therefore be appropriate in those centers where the requisite level of expertise is available.

Distal Radius Fracture

As is true for many joints of the extremities, a 2-view radiographic examination is not adequate for detecting fracture in the wrist, hand, or fingers [5]. In most patients with suspected distal radius fractures**,** a 3-view radiographic examination (posteroanterior [PA], lateral, and 45° semipronated oblique) suffices [6], whereas one study [7] suggests that the routine addition of a fourth projection—a semisupinated oblique projection—would increase the yield for distal radius fractures, which may be visible only on this fourth view. Nevertheless, when high-field or low-field MRI is performed in addition to radiographs, radiographically occult fractures of the distal radius as well as unsuspected fractures of the carpal bones are frequently demonstrated [8-11]. In injured wrists with normal or suspicious radiographic findings that do not account for the clinical symptoms, MRI results in a change in diagnosis in 55% of cases and a change in management in 66% of cases [9]. However, a randomized controlled trial showed that routine performance of an immediate, abbreviated, low-field MRI study in acutely injured wrists did not predict the need for further treatment any better than the combination of physical examination and radiography [10]. Furthermore, there was no statistically significant difference in outcomes measures—including quality of life, time lost from work, and total costs—with this strategy compared to performing radiographs alone [12]. In addition to MRI, multidetector CT (MDCT) can show radiographically occult carpal fractures and exclude or confirm suspected fractures when initial radiographs are equivocal [13]. MRI is a more appropriate modality to use before CT if there are no contraindications to MRI [14]. CT has an important role in treatment planning when initial radiographs show a complex fracture-dislocation of the carpus.

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Successful treatment of distal radius fractures is predicated on the re-establishment of radial length, inclination, and tilt, as well as the restoration of the articular surfaces [6,15]. Specifically, the presence of a coronally oriented fracture line, die-punch depression, and more than 3 articular surface fragments may indicate the need for operative reduction [16]. Less than 2 mm residual step-off of the distal radial articular surface is considered a congruent reduction necessary for good long-term outcome [9,15]. Most patients with intra-articular fractures of the distal radius develop radiographic radiocarpal osteoarthritis that progresses over time, even when the original fracture was treated with open reduction and internal fixation; however, the development of radiographic osteoarthritis does not correlate with function even 15 years after initial injury [17]. CT examination reveals involvement of the radiocarpal and distal radioulnar articular surfaces, intra-articular displacements and depressions, and comminution more accurately than radiographs [15,18,19].

Measurements of articular surface gap and step-off are more reproducible when performed by comparing CT to radiographs. For displacements >2 mm, there is poor correlation between radiographic and CT findings [18]. Thus, in distal radius fractures where there is a high likelihood of intra-articular incongruence (eg, fractures in young adults, which frequently result from high-energy impact loading), selective or even routine use of CT to supplement the standard radiographic examination is warranted. The distal radial articular surface is best evaluated by MDCT with multiplanar reformatted images; if MDCT is not available, direct sagittal images can be obtained, but the imaging process may be difficult if the patient has a cast or external fixator. The addition of 3-D surface-rendered reconstructions to the standard 2-D CT images may increase interobserver agreement and will change planned management of intra-articular distal radius fractures in up to 48% of cases [16]. MRI also shows intra-articular extension of distal radius fractures more frequently than does radiography and demonstrates concomitant intra-articular soft-tissue injuries—predominantly tears of the scapholunate interosseous ligament—that may affect surgical treatment [20,21]. However, current evidence suggests that MRI performed immediately at the time of injury has no added value for predicting whether additional treatment will be necessary for soft-tissue injuries [10]. CT is recommended over MRI for surgical planning of complex, intra-articular distal radius fractures.

Distal Radioulnar Joint Subluxation

The diagnosis of distal radioulnar joint (DRUJ) subluxation is problematic. The symptoms and physical findings are often nonspecific, and the condition is difficult to confirm radiographically. Traumatic subluxation or dislocation of the DRUJ may occur as an isolated injury or be associated with other conditions. If optimum positioning of the wrist is not possible because of the injury or overlying cast, CT scanning is recommended [22-24]. Both wrists should be scanned simultaneously in both pronated and supinated positions [24]. Although this examination can also be performed with MRI, repositioning the patient and scanning both wrists is logistically more complex, more time-consuming, and less comfortable with MRI compared to CT.

Scaphoid Fracture

An additional fourth radiographic projection—an elongated PA view with approximately 30° of cephalad beam angulation and the wrist positioned in 10°–15° of ulnar deviation—is routinely recommended whenever there is clinical suspicion of a scaphoid fracture [6,25]. However, scaphoid fractures are notoriously difficult to see on initial radiographs (regardless of the views) and are radiographically occult in up to 20% of cases. Standard practice in patients with clinically suspected scaphoid fractures but normal initial radiographs is to apply a cast and to repeat the clinical evaluation and radiographs in 10–14 days when resorption at the fracture line may make previously occult fractures visible. If the repeat radiographs are still normal or equivocal at that time and there continues to be a strong clinical suspicion of scaphoid fracture, imaging with a second modality—bone scintigraphy, CT, or MRI—is indicated. There is little evidence favoring either scintigraphy or CT in this scenario [26,27], although a recent meta-analysis found that MRI is superior to scintigraphy for showing occult scaphoid fractures [28]. A survey of worldwide institutions found that MRI is most commonly used in these cases, although many hospitals still perform CT or scintigraphy, and the choice of modality often depends on local preferences, expertise, and equipment [29].

The role of tomography, ultrasonography, scintigraphy, CT, and MRI (with standard equipment or a dedicated, extremity-only scanner) has been evaluated in uncertain cases of scaphoid fracture at the time of or shortly after the initial injury. If one or more of these studies is sufficiently sensitive and specific, presumptive casting can be eliminated in normal cases, and definitive care can be instituted earlier for fractures [30-37].

Bone scintigraphy, with either delayed images or blood pool images, can be used to identify or exclude radiographically occult scaphoid fractures [37,38], but this use of scintigraphy has been largely replaced by MRI, which is both more sensitive and more specific than scintigraphy. Scintigraphic false-positive diagnoses of carpal fractures occur due to bone contusions, osteoarthritis, avascular necrosis, and osteomyelitis, any of which may be radiographically occult [39]. MRI evaluation for radiographically occult scaphoid fractures can be performed using high-field or low-field equipment, a whole-body imaging system and appropriate local coil, or a dedicated extremity MR scanner [32,33]. Not only can MRI accurately show scaphoid fractures, but in cases where no scaphoid fracture is present, MRI often demonstrates other unsuspected fractures of the distal radius or carpus or soft-tissue injuries [31-33,36]. In this role, MRI may be cost-effective, especially if immediate MR examination is performed in lieu of presumptive casting, if MRI is done with a limited protocol and at a reduced charge, and if the total cost of presumptive care, including productivity lost from work, is included in the analysis [40]. One recent study suggested that MRI should be used as the "reference standard" for suspected scaphoid fractures, since their study showed the specificity of MRI to be quite high, at 96% [41]; however, this opinion is not universally held. Another recent study rated the positive predictive value of MRI for scaphoid fracture at only 88% [42].

Ultrasonography with high-frequency transducers can identify some cases of radiographically occult scaphoid fractures [34,43]; however, the current evidence does not support the routine use of sonography in these cases outside of specialized centers where the appropriate level of expertise is available. Ultrasound (US) is not sensitive enough to preclude presumptive casting when no fracture is seen [43-45]. Furthermore, US only interrogates the dorsal scaphoid waist, whereas a large proportion of wrists with clinically suspected occult scaphoid fractures in reality have a fracture of the distal radius or other carpal bone (or another portion of the scaphoid); all these cases would be missed if a negative US examination were used as the basis to avoid casting [31-34,36,39]. CT examination is more sensitive and specific than scintigraphy for diagnosing radiographically occult scaphoid fractures [46], though it is less sensitive (and shows fewer additional fractures) than MRI in such a situation [47]. Nevertheless, CT is a reasonable alternative to immediate MRI with a claustrophobic patient or when there is a contraindication to MRI.

Accuracy for scaphoid fracture detection according to Ring et al [48] is 99% for MRI, 98%for CT, 93% for bone scintigraphy, and 92%for sonography, although the number of patients studied were relatively few.

In summary, radiographically occult scaphoid fractures are relatively common and cause future morbidity when missed. In patients with a strong clinical suspicion of a scaphoid fracture but normal radiographs, either presumptive casting with repeated radiographs in 10–14 days or immediate MRI are equally acceptable strategies. The choice will depend on the age of the fracture, hand dominance, activity level of the patient, the availability of MRI, and local preferences. If repeat radiographs are normal, the patient remains symptomatic, and further imaging is required, MRI is the study of choice. For patients with contraindications to MRI, CT is preferred to scintigraphy. Sonography may be an appropriate alternative in those centers where the appropriate level of expertise is available.

For the scaphoid bone, not only is identification of the fracture important, but many surgeons also recommend immediate operative intervention for displaced scaphoid fractures. As little as 1 mm of displacement is important, resulting in a higher rate of nonunion and avascular necrosis [6]. Although CT scanning confined to the direct sagittal plane will underestimate radial or ulnar displacement of scaphoid fractures [49], evaluations with MRI [50] or multiplanar and/or 3-D reconstructions from MDCT [51] are more sensitive than standard radiographs for showing small amounts of displacement. In cases where malposition of the scaphoid fracture fragments is suspected despite normal radiographs, CT is recommended. Similarly, CT examination is recommended when there is a question about the age of a scaphoid fracture or its healing.

Hook of the Hamate Fracture

Compared with the scaphoid, the diagnosis of other carpal bone injuries is less problematic. In specific circumstances, however, supplemental studies in addition to the standard wrist examination are useful. Pisiform fractures are best seen on semisupinated AP or carpal tunnel projections, which project the pisiform volar to the rest of the carpus.

The same projections may also demonstrate fractures involving the hook of the hamate that are not visible on the standard radiographs. However, if radiographs fail to show a hamate fracture that is strongly suspected clinically, axial CT examination is indicated [6,52].

Metacarpal and Phalangeal Fracture

A standard 3-view radiographic examination will reveal most fractures and dislocations of the metacarpals and phalanges [5]. CT may be useful for surgical planning in fracture-dislocations of the carpometacarpal joints. For phalangeal injuries, some practices include a PA examination of the entire hand, whereas others limit the entire examination to the injured finger. An internally rotated oblique projection in addition to the standard externally rotated oblique may increase diagnostic confidence for phalangeal fractures [53]. Unlike the case for the wrist, low-field MRI is less sensitive than radiographs for hand and finger fractures [11], and its role is limited to cases where specific abnormalities of the soft tissues—including the collateral ligaments, volar plates, tendons, and pulleys—would affect treatment.

Thumb Fracture

Most fractures of the thumb will be visible on a 2-view radiographic examination, although there is a slight increase in diagnostic yield with the addition of an oblique projection [5], which can be obtained along with a PA examination of the whole hand. Tears of the ulnar collateral ligament of the thumb metacarpophalangeal joint (gamekeeper injury) represent a special problem. Unless there is an associated bony avulsion of the distal metacarpal or proximal phalangeal base, the injury will be radiographically occult. In these cases, a stress examination of the joint with manually applied abduction stress (which can be applied by the patient or the examiner) may show subluxation compared to the contralateral, uninjured side [54,55], although there is a theoretical risk of converting a nondisplaced ulnar collateral ligament tear into a displaced one by a stress examination [55,56]. More important for treatment planning is whether the adductor aponeurosis has become interposed between the torn, displaced ligament and its osseous attachment site—a so-called Stener lesion. Torn ligaments with a Stener lesion require operative repair, although most nondisplaced tears without an interposed aponeurosis will heal with conservative treatment. Conventional arthrography, US, MRI, and MR arthrography have each been advocated to distinguish ulnar collateral ligament tears with and without Stener lesions [55-60]. The choice of which modality to use will depend on local availability and expertise.

Summary

- Radiographs should be the first imaging study in patients with acute wrist, hand, or finger injuries. The examination must include the correct radiographic projections, which in turn depend on an accurate, site-specific clinical history.
- Nondisplaced wrist fractures, especially those of the distal radius and scaphoid, may be radiographically occult initially; in cases where there is a strong clinical suspicion of a fracture despite normal radiographs, further evaluation with immobilization and repeat radiographs, CT, or MR imaging is indicated, depending on the clinical circumstances.
- CT has additional roles for evaluating the articular surfaces in intra-articular fractures and for detecting specific injuries, including fractures of the hook of the hamate, subluxations of the distal radioulnar joint, and fractures and dislocations of the metacarpal bases.
- For many indications, including scaphoid bone injuries and ligament injuries at the base of the thumb, MR imaging is the most sensitive examination.
- Sonography may also be appropriate in specialized centers, both in detection of fractures and evaluation of injuries to the stabilizing ligaments of the wrist.

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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