American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)**

Variant 1: **Suspected osteomyelitis, septic arthritis, or soft-tissue infection (excluding spine and diabetic foot). First study.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9		Varies
CT area of interest with IV contrast	1		Varies
CT area of interest without IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
MRI area of interest without IV contrast	1		O
MRI area of interest without and with IV contrast	1		O
US area of interest	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: **Soft-tissue or juxta-articular swelling. Suspected soft-tissue infection. Additional imaging following radiographs.**

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without and with IV contrast	9	Radiographs and MRI are both indicated and complementary. This procedure provides better delineation of fluid collection and areas of necrosis with contrast.	O
MRI area of interest without IV contrast	7	This procedure is an alternative to MRI without and with contrast if contrast is contraindicated.	O
CT area of interest with IV contrast	6	Contrast is preferred to help with soft-tissue evaluation if it can be given.	Varies
US area of interest	5	This procedure may be useful following radiographs for evaluation of juxta-articular regions.	O
CT area of interest without IV contrast	4		Varies
CT area of interest without and with IV contrast	1		Varies
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Clinical Condition: **Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)**

Variant 3: **Soft-tissue or juxta-articular swelling with a history of puncture wound. Suspected foreign body. Negative radiographs.**

Radiologic Procedure	Rating	Comments	RRL*
US area of interest	8	This procedure is an alternative to CT and MRI. It is favored for radiolucent (wood, plastic) foreign body.	O
CT area of interest without IV contrast	7	This procedure is an alternative to MRI and US. It is recommended to assess for radiopaque foreign body.	Varies
MRI area of interest without and with IV contrast	7	This procedure is an alternative to CT and US for assessing extent of infection. CT is favored over MRI for identification of foreign bodies.	O
CT area of interest with IV contrast	6	Contrast may obscure identification of the foreign body.	Varies
MRI area of interest without IV contrast	6		O
CT area of interest without and with IV contrast	1		Varies
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Clinical Condition: **Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)**

Variant 4: **Soft-tissue or juxta-articular swelling with cellulitis and a skin lesion, injury, wound, ulcer, or blister. Suspected osteomyelitis. Additional imaging following radiographs.**

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without and with IV contrast	9	Radiographs and MRI are both indicated and complementary.	O
MRI area of interest without IV contrast	7	This procedure is an alternative to MRI without and with contrast if contrast is contraindicated. Contrast is preferred to aid in soft-tissue evaluation.	O
CT area of interest with IV contrast	7	This procedure is an alternative if MRI is contraindicated.	Varies
WBC scan and sulfur colloid scan foot	6		☢☢☢☢
3-phase bone scan and WBC scan area of interest	6	SPECT improves sensitivity.	☢☢☢☢
CT area of interest without IV contrast	5		Varies
3-phase bone scan area of interest	5	SPECT improves sensitivity.	☢☢☢
FDG-PET/CT area of interest	2		☢☢☢☢
CT area of interest without and with IV contrast	1		Varies
US area of interest	1		O
WBC scan area of interest	1		☢☢☢☢
3-phase bone scan and WBC scan and sulfur colloid scan area of interest	1		☢☢☢☢
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Clinical Condition: **Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)**

Variant 5: **Soft-tissue or juxta-articular swelling with a history of prior surgery. Suspected osteomyelitis or septic arthritis. Additional imaging following radiographs.**

Radiologic Procedure	Rating	Comments	RRL*
Aspiration area of interest	9	This procedure is recommended if there is concern for septic arthritis.	Varies
MRI area of interest without and with IV contrast	9	This procedure is recommended for evaluation of osteomyelitis and extent of infection. It may be complementary to aspiration for evaluation of septic arthritis. Contrast is preferred if not contraindicated.	O
MRI area of interest without IV contrast	7	This procedure is recommended for evaluation of osteomyelitis and extent of infection. It may be complementary to aspiration for evaluation of septic arthritis. Contrast is preferred if not contraindicated.	O
CT area of interest with IV contrast	6	This procedure may be helpful if MRI is contraindicated or extensive MRI artifact from metal is present.	Varies
CT area of interest without IV contrast	5	This procedure may be helpful if MRI is contraindicated or extensive MRI artifact from metal is present.	Varies
WBC scan and sulfur colloid scan area of interest	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	☢☢☢☢
WBC scan area of interest	2		☢☢☢☢
3-phase bone scan and WBC scan area of interest	2		☢☢☢☢
CT area of interest without and with IV contrast	1		Varies
US area of interest	1		O
3-phase bone scan area of interest	1		☢☢☢
3-phase bone scan and WBC scan and sulfur colloid scan area of interest	1		☢☢☢☢
FDG-PET/CT area of interest	1	This is promising new technology but data are limited.	☢☢☢☢
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Clinical Condition: **Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)**

Variant 6: **Pain and swelling or cellulitis associated with site of previous nonarthroplasty hardware. Suspected osteomyelitis or septic arthritis. Additional imaging following radiographs.**

Radiologic Procedure	Rating	Comments	RRL*
Aspiration area of interest	9	This procedure is recommended if there is concern for septic arthritis.	Varies
MRI area of interest without and with IV contrast	9	This procedure is recommended for evaluation of osteomyelitis and extent of infection. It may be complementary to aspiration for evaluation of septic arthritis.	O
MRI area of interest without IV contrast	8	This procedure is an alternative to MRI without and with contrast if contrast is contraindicated.	O
CT area of interest with IV contrast	7	This procedure is an alternative if MRI is contraindicated or extensive MRI artifact from metal is present.	Varies
WBC scan and sulfur colloid scan area of interest	7	This procedure is an alternative to CT and MRI if extensive hardware is present.	☢☢☢☢
CT area of interest without IV contrast	5		Varies
WBC scan area of interest	2		☢☢☢☢
3-phase bone scan area of interest	2		☢☢☢
3-phase bone scan and WBC scan area of interest	2		☢☢☢☢
FDG-PET/CT area of interest	2		☢☢☢☢
CT area of interest without and with IV contrast	1		Varies
US area of interest	1		O
3-phase bone scan and WBC scan and sulfur colloid scan area of interest	1		☢☢☢☢
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Clinical Condition: **Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)**

Variant 7: **Draining sinus (not associated with a joint prosthesis). Suspected osteomyelitis. Additional imaging following radiographs.**

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without and with IV contrast	9		O
MRI area of interest without IV contrast	7	This procedure is an alternative to MRI without and with contrast. Contrast is preferred if not contraindicated.	O
CT area of interest with IV contrast	6	This procedure may be useful if MRI is contraindicated or extensive MRI artifact from metal is present.	Varies
CT area of interest without IV contrast	6	This procedure may be useful if MRI is contraindicated or extensive MRI artifact from metal is present.	Varies
CT area of interest without and with IV contrast	3		Varies
US area of interest	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: **Clinical examination suggesting crepitus. Suspected soft-tissue gas. First study.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9		Varies
CT area of interest with IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating. X-ray is the preferred initial study. Contrast is preferred for evaluation of possible concomitant soft-tissue abscess.	Varies
CT area of interest without IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating. X-ray is the preferred initial study. This procedure may be appropriate if there is contraindication to contrast.	Varies
CT area of interest without and with IV contrast	1		Varies
MRI area of interest without IV contrast	1		O
MRI area of interest without and with IV contrast	1		O
US area of interest	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: **Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)**

Variant 9: **Initial radiographs showing soft-tissue gas in absence of puncture wound.**

Radiologic Procedure	Rating	Comments	RRL*
CT area of interest without IV contrast	6	CT is useful due to rapid acquisition and high sensitivity.	Varies
CT area of interest with IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating. CT is useful due to rapid acquisition and high sensitivity.	Varies
MRI area of interest without IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	O
MRI area of interest without and with IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	O
CT area of interest without and with IV contrast	1		Varies
US area of interest	1		O
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

SUSPECTED OSTEOMYELITIS, SEPTIC ARTHRITIS, OR SOFT TISSUE INFECTION (EXCLUDING SPINE AND DIABETIC FOOT)

Expert Panel on Musculoskeletal Imaging: Francesca D. Beaman, MD[1]; Paul F. von Herrmann, MD[2]; Mark J. Kransdorf, MD[3]; Ronald S. Adler, MD, PhD[4]; Behrang Amini, MD, PhD[5]; Marc Appel, MD[6]; Erin Arnold, MD[7]; Stephanie A. Bernard, MD[8]; Bennett S. Greenspan, MD, MS[9]; Kenneth S. Lee, MD, MBA[10]; Michael J. Tuite, MD[11]; Eric A. Walker, MD[12]; Robert J. Ward, MD[13]; Daniel E. Wessell, MD[14]; Barbara N. Weissman, MD.[15]

Summary of Literature Review

Introduction/Background

Osteomyelitis is a common problem in clinical practice. Contiguous spread from a soft-tissue infection, direct inoculation following surgery or trauma, and hematogenous seeding during bacteremia all can lead to bone infection. Early detection and diagnosis are key to preventing chronic bone destruction and resultant deformity. Although rare, squamous cell carcinoma can arise in chronic soft-tissue sinus tracts associated with osteomyelitis. Differentiating soft-tissue from osseous infection often determines the appropriate clinical therapeutic course. Imaging plays a central role in characterizing soft-tissue and osseous infections by identifying the location, evaluating the extent of involvement, and detecting complications such as soft-tissue abscesses or sinus tracts.

Hematogenous seeding (primarily affecting the metaphyses of long bones) is the primary form of osteomyelitis seen in the pediatric population. Although the average age is 10 years, >50% of cases occur in patients 5 years and younger [1-4]. The majority involves the lower extremities [2,3].

Septic arthritis, or joint infection, is a rapidly progressive, debilitating process noted for significant morbidity or mortality. Patients typically present with pain localized to a single joint, erythema, soft-tissue swelling, and diminished range of motion [5]. In children, over half of cases occur in the 2- to 3-year-old age range and below, with the majority involving lower-extremity joints [2].

Overview of Imaging Modalities

Because radiographs are safe, inexpensive, quickly obtained, and widely available, they should be the initial imaging test in cases of suspected musculoskeletal infection [6-8]. Although often not diagnostic in acute osteomyelitis, they provide anatomic evaluation of the affected site, depict changes of chronic osteomyelitis, can reveal gas or foreign bodies, and can suggest alternative diagnoses such as neuropathic arthropathy, fracture, or tumor, which influence subsequent imaging selection and interpretation. Fluoroscopy plays a role in directing joint aspirations to differentiate inflammation and infection.

With its inherent sensitivity for bone marrow abnormalities, superb soft-tissue contrast, and delineation of anatomic detail, magnetic resonance imaging (MRI) is the modality of choice for suspected bone and extremity soft-tissue infections. It likewise is the standard for evaluating the extent of osseous and soft-tissue involvement and for following treatment response. Although MRI does offer additional advantages, including multiplanar imaging and lack of ionizing radiation, drawbacks include potential difficulty in distinguishing infection from reactive inflammation, artifact produced by orthopedic hardware, and patient contraindications such as non–MRI-compatible implanted devices or severe claustrophobia. MRI has a 100% negative predictive value for excluding osteomyelitis; a normal marrow signal reliably excludes infection [7,9]. Positive cases show decreased T1-weighted bone marrow signal, with increased signal on fluid-sensitive sequences such as T2-weighted fat-saturated and short tau inversion recovery. Studies have confirmed both high sensitivity and high specificity of T1-weighted signal abnormalities for assigning true positive and true negative in suspected osteomyelitis [10,11].

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As with adults, MRI is the modality of choice for evaluating osseous infection in the pediatric population, particularly given radiation dose concerns [1,3].

Computed tomography (CT) depicts cortical bone well and so can play a role in the diagnosis of chronic osteomyelitis. Periosteal reaction, bone destruction, necrotic bone (sequestra), and sinus tracts are evident on CT, as are soft-tissue infections such as cellulitis and abscess. CT is particularly sensitive to soft-tissue gas (that can signal necrotizing fasciitis) and foreign bodies. CT in fact is superior to MRI for the diagnosis of sequestra, foreign bodies, and gas [12,13].

Ultrasound (US) plays a complementary role in the evaluation of osteomyelitis, primarily for detection and characterization of soft-tissue infections. US excels in detecting subperiosteal and soft-tissue abscesses, tenosynovitis, joint effusions, and radiolucent foreign bodies (eg, wood or plastic). Both CT and US can be used in cases of percutaneous abscess drainage. In some clinical circumstances, US is favored for ease of use and lack of ionizing radiation. Similarly, US can be used for joint aspiration.

Nuclear medicine examinations have long been used in the detection of infection, but their role now largely is limited to cases where MRI is contraindicated, infection is multifocal, or when the infection is associated with orthopedic hardware or chronic bone alterations from trauma or surgery. Skeletal scintigraphy is highly sensitive but lacks specificity. Bone scans can become positive as early as 1–2 days after the onset of clinical symptoms. A 3- or 4-phase bone scan aids in distinguishing cellulitis from osteomyelitis. Combining bone scintigraphy with a labeled leukocyte scan enhances sensitivity. A labeled leukocyte scan in concert with Tc-99m sulfur colloid marrow imaging is particularly useful in cases with altered bone marrow distribution, such as joint prosthesis.

The addition of single-photon emission CT (SPECT) or SPECT/CT improves the accuracy of radionuclide scintigraphy, facilitating the differentiation between bone and soft-tissue infection [14-17]. Fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography (FDG-PET) has shown high accuracy in the detection of osteomyelitis in patients with prior surgery, trauma, and orthopedic hardware [18,19]. A recent meta-analysis confirmed the superiority of FDG-PET to other radionuclide examinations, with a pooled sensitivity of 92% and specificity of 92% [20]. In children, nuclear medicine examinations for the diagnosis of infection are less common, reflecting the wide availability of MRI (including whole-body MRI) and radiation exposure concerns.

Discussion of Imaging Modalities by Variant

Variant 1: Suspected osteomyelitis, septic arthritis, or soft-tissue infection (excluding spine and diabetic foot). First study.

In adults, the likelihood of developing osteomyelitis without an associated wound or ulceration of the adjacent soft tissue is extremely low. Thus, in the absence of a wound, the role of imaging is to diagnose soft-tissue (or less likely joint) infection to determine its extent, identify complications, and exclude other pathologies such as vascular insufficiency, fracture, or foreign body. Initial investigation should begin with radiographs to outline anatomic detail, evaluate for radiodense foreign bodies or soft-tissue gas, and exclude alternate diagnoses such as fracture, degenerative changes, or tumor.

Although radiographs are recommended as an initial screening examination, they are insensitive in the detection of acute osteomyelitis. Subtle early radiographic findings of osteomyelitis include soft-tissue swelling and obscuration of the fat planes [9]. Following 1–2 weeks, osteolysis, cortical loss, and periosteal reaction ensue [8].

Variant 2: Soft-tissue or juxta-articular swelling. Suspected soft-tissue infection. Additional imaging following radiographs.

CT [13] and MRI are well suited to delineate the anatomic extent of soft-tissue infections, and both offer multiplanar capability. MRI is favored for its greater sensitivity in detecting inflammation as well as associated fasciitis, myositis, and areas of necrosis [3,21-24]. US is valuable in the detection of soft-tissue fluid collections, foreign bodies, and joint effusions. Some would assert, though, that it has a more limited role, as it can underestimate disease extent, has limited visualization of deeper structures, and is hindered by bone and gas [3,25]. Sonography is more valuable in young children, with their larger cartilage-to-bone ratio and small body size. Lack of radiation, no need for sedation, and bedside imaging capability are additional advantages [25].

In general, nuclear medicine studies are limited by low spatial resolution and low specificity in the evaluation of soft-tissue infections and are more suited for assessing osseous infections. If septic arthritis is suspected, joint aspiration should be performed either by the radiologist or the referring service. The reference standard for the diagnosis of a septic joint is a positive culture from joint aspirate; however, a negative culture does not exclude the diagnosis, especially if the patient is already on antibiotic therapy [5].

Variant 3: Soft-tissue or juxta-articular swelling with a history of puncture wound. Suspected foreign body. Negative radiographs.

In patients with a puncture wound, any imaging evaluation should determine presence or absence of a retained foreign body. Such retained material in the soft tissue triggers a granulomatous reaction, and subsequently a soft-tissue infection can develop. Radiographs are indicated for initial imaging, especially if the composition of the material is unknown, and are well suited in the detection of radiodense foreign bodies such as metal, graphite, and stone. Glass is inconsistently visible radiographically, particularly if fragments are small or obscured by adjacent osseous structures [26]. Optimal imaging for radiolucent (eg, plastic or wood) material is US. Both US and CT allow for precise foreign body localization. CT is favored over MRI for identification of foreign bodies, being well suited for detection of radiodense bodies and wood. US, CT, and MRI have roles in the evaluation of concomitant soft-tissue infections as outlined in the discussion of Variants 1 and 2 above.

Variant 4: Soft-tissue or juxta-articular swelling with cellulitis and a skin lesion, injury, wound, ulcer, or blister. Suspected osteomyelitis. Additional imaging following radiographs.

MRI is the preferred imaging modality in the evaluation of acute osteomyelitis, with high sensitivity and specificity; importantly, a negative examination excludes osteomyelitis [23,27,28]. MRI has high sensitivity, specificity, and interobserver agreement in the assessment of marrow edema and cortical erosions [10,11,29,30]. Additionally, MRI is best suited for evaluation of the extent of osseous and soft-tissue involvement, including the presence of abscesses. Unless contraindicated, contrast should be administered for evaluation of soft tissues, articular and tendon involvement, and delineation of areas of necrosis [31]. CT offers an alternative when MRI is contraindicated, with the caveat that it is inferior to MRI in evaluation of extent of bone infection and associated soft-tissue involvement [23]. CT best depicts bone changes in chronic infection [13]. Although debated, US generally is thought to be of limited value.

In evaluating suspected osteomyelitis, bone scintigraphy is most useful when the scan is negative; unfortunately, a positive study can be nonspecific. In positive cases of acute osteomyelitis, tracer uptake is present on all phases. In a meta-analysis by Wang et al [20] overall sensitivity was 83% and negative predictive value was .83, but specificity was only 45% for detection of osteomyelitis. Surprisingly, labeled leukocyte scanning likewise carries a low specificity [32,33] and thus is not useful as a single examination. The combination of labeled leukocyte scan with Tc-99m sulfur colloid or Tc-99m 3-phase bone scan improves specificity in the evaluation of acute infection. Sulfur colloid imaging can distinguish normal marrow from infection, as there is no tracer accumulation in infection. The diagnostic role of FDG-PET for combined evaluation of acute and chronic bone and soft-tissue infection continues to evolve, with sensitivities as high as 95% and specificities from 75%–99% [34]. However, its capability for diagnosing chronic osteomyelitis and spinal infections offers greater promise [18,34-36]. Currently, there is no evidence supporting a role for FDG-PET in the evaluation of septic arthritis since FDG also accumulates in inflammatory arthritis [34].

Variant 5: Soft-tissue or juxta-articular swelling with a history of prior surgery. Suspected osteomyelitis or septic arthritis. Additional imaging following radiographs.

Variant 6: Pain and swelling or cellulitis associated with site of previous nonarthroplasty hardware. Suspected osteomyelitis or septic arthritis. Additional imaging following radiographs.

Radiographs reveal information about hardware and bone fractures, such as evidence of hardware loosening or fracture, degree of bone fracture healing or nonunion, and presence of heterotopic ossification. Chronic osteomyelitis occurs if residual infection is inadequately treated or refractory to therapy and can result from continuous infection or reactivation. Radiographs depict bone sclerosis and areas of destruction. Although complementary, radiography should not be the sole or primary imaging modality.

The use of US is debated. Fistulous tracts, periosteal thickening, cortical discontinuity, juxtacortical fluid, and soft-tissue abscess have been described as sonographic signs of reactivated osteomyelitis in the setting of prior trauma or surgery [37]. Unfortunately, the study design did not assess the presence of these findings in a control group. Additionally, US is limited by metal artifact, inability to detect bone abnormalities, and nonspecificity of subperiosteal fluid collections [12]. CT is well suited for evaluation of fracture nonunion, hardware complications, and developing or worsening osteolysis. Features of chronic osteomyelitis on CT include periosteal reaction, trabecular coarsening, bone fragmentation, cortical erosions, and fistulae [35], but these features are nonspecific in the setting of trauma. Cortical abnormalities should be evaluated with caution, as they could be secondary to the trauma or surgery.

Although MRI is exceptional in the detection of acute osteomyelitis, detecting acute osseous changes in the setting of chronic post-traumatic osteomyelitis is challenging in the setting of bone altered by prior trauma or surgery. MRI is sensitive in chronic osteomyelitis, depicting soft-tissue and marrow edema, as well as alterations in tissue perfusion. Marrow signal heterogeneity following trauma or surgery limits detection of superimposed infection, as reparative fibrovascular scar tissue in the bone marrow and soft tissues can persist following surgical intervention, mimicking infection [21]. Both CT and MRI are susceptible to hardware artifact, although technological advances with the development of artifact-reducing protocols mitigate this shortcoming.

In a meta-analysis focused on chronic osteomyelitis, bone scintigraphy sensitivity was reasonable at 82%, but specificity was poor at 25% [36]. Scintigraphic findings of infection are difficult to distinguish from postoperative or degenerative changes [12]. In meta-analyses, sensitivity of leukocyte scanning ranged from 61%–74% and specificity from 77%–88% [20,36]. There was, however, particularly low leukocyte scan sensitivity (21%) in cases of chronic osteomyelitis involving the axial skeleton [36]. Uptake at healing fracture sites complicates bone scintigraphy [12]. Leukocytes are not incorporated into areas of bone turnover, so white cell scans remain useful in the setting of prior trauma. Prior surgery can alter marrow distribution, and the combination of labeled leukocyte scanning with Tc-99m sulfur colloid improves examination specificity in the evaluation of acute infection.

Differentiating between infection and inflammation on FDG-PET can be impossible in the acute postoperative or post-traumatic setting [38]. FDG tracer accumulation might not normalize until 3–4 months after surgery or trauma [34]. In PET, fractures are the most common cause of false-positive results [39]. In a small study of 33 trauma patients suspected of having chronic osteomyelitis, the sensitivity of FDG–PET was 94% and specificity was 87%. Specificity increased to 100% when evaluation was limited to the axial skeleton. Eighteen of the 33 patients had metallic hardware, and all patients were imaged at least 6 months following trauma or surgery. In this study, 2 false positives were ascribed to a prosthesis foreign body reaction and a fracture nonunion, with 1 false negative in mandibular necrosis [35]. Chacko et al [18] showed FDG-PET accuracy of 96% for detecting infection in the setting of orthopedic hardware (primarily joint prosthesis), 91% in chronic osteomyelitis, 92% in detecting osteomyelitis in the setting of soft-tissue infections, and 87% in post-traumatic/surgical patients. These results bolster the potential diagnostic utility of FDG-PET in cases of chronic osteomyelitis or when hardware is present.

If septic arthritis is suspected prompt diagnosis and treatment are essential. Depending on the virulence of the organism, cartilage destruction can ensue rapidly, with consequent osseous erosions and osteomyelitis. Synovial thickening and enhancement, joint effusion, and inflammatory change in the juxta-articular tissue are typical imaging findings, though joint effusion can be absent in up to one-third of adult patients with septic arthritis [27]. Early joint aspiration for diagnosis is recommended. Laboratory evaluation should include routine cultures, Gram stain, and cell count with differential [5]. Both fluoroscopy and US can be used for joint aspiration and allow confirmation of the needle placement.

Variant 7: Draining sinus (not associated with a joint prosthesis). Suspected osteomyelitis. Additional imaging following radiographs.

A draining sinus should prompt a high clinical suspicion for chronic infection. While a well-described complication of chronic osteomyelitis, sinuses also can be secondary to abscess formation from a retained foreign body. Persistent bone infection results in continuous infection of the overlying soft tissue, with consequent formation of a sinus tract to allow pus drainage through the skin [37]. Initial imaging typically includes radiographs of the affected bone or joint [5]. US will detect abscesses or joint fluid and can guide percutaneous aspiration. Both MRI and CT are sensitive in the diagnosis of chronic osteomyelitis, revealing cortical thickening, cortical destruction, and soft-tissue involvement. CT will show effusions and soft-tissue fluid collections, with depiction of bone erosions more striking than on radiographs [23]. MRI is superior in delineating the extent of involved versus uninvolved bone marrow, as well as intraosseous abscess. CT better depicts sequestrum, cloaca, and osseous erosion [12,13,21]. Both can detect concomitant squamous cell carcinoma in a chronic sinus tract.

In a meta-analysis evaluating 23 articles comprising 1269 diagnostic evaluations for chronic osteomyelitis in 687 patients, pooled sensitivity and specificity for PET were 96% and 91%, respectively [36]. Sensitivity suffers, however, in the setting of extensive soft-tissue inflammation or infection. An additional limitation is decreased ability to detect extent of disease without the addition of CT.

Injection of contrast medium into the fistula directly reveals whether it extends to or within bone and has been shown to surround a sequestrum [12]. This procedure is rarely called for, given the ubiquity of CT and MRI availability.

Evaluation of suspected infection with joint prosthesis is reported in separate ACR Appropriateness Criteria®.

Variant 8: Clinical examination suggesting crepitus. Suspected soft-tissue gas. First study.

Articular crepitus—joint grating or popping—most commonly is associated with arthritis. Conversely, extremity soft-tissue crepitus could represent soft-tissue gas, so a history of recent surgical intervention, trauma (subcutaneous emphysema), or puncture wound should be sought. Radiographs are well suited for the detection of soft-tissue gas in the extremities or juxta-articular tissues but are limited in evaluation of deep fascial gas [22,40]. CT is the most sensitive means of detection of soft-tissue gas and can delineate extent and compartmental location [22]. MRI is less sensitive than CT in the detection of soft-tissue gas. Gradient-echo imaging is useful in identifying air on MR by magnifying the susceptibility artifact [41]. There is no role for nuclear scintigraphy.

Variant 9: Initial radiographs showing soft-tissue gas in absence of puncture wound.

In the absence of recent surgery, trauma, or puncture wound, soft-tissue gas is a reliable indication of infection [12]. Gas in the deep fascial planes is a hallmark of necrotizing fasciitis and can be diagnosed radiographically [23]. Necrotizing fasciitis is rapidly progressive, can be life-threatening, and when suspected should be treated with surgical debridement. This infection can be difficult to diagnose early or when soft-tissue gas is not present; thus, cross-sectional imaging can play a vital role in early recognition. Fascial thickening, fluid collections along the deep fascial planes, and intermuscular septal edema are MRI and CT features of deep fascial inflammation. Postcontrast imaging is favored, as lack of enhancement confirms tissue necrosis, distinguishing necrotizing from non-necrotizing fasciitis. CT remains the most sensitive modality for identification of soft-tissue gas and is preferred in some situations due to rapid acquisition [13].

Summary of Recommendations

- MRI with contrast is the modality of choice in the evaluation of osteomyelitis.
- Radiographs provide anatomic evaluation, demonstrate findings of chronic osteomyelitis, and can reveal gas or foreign bodies. They might suggest alternative diagnoses such as neuropathic arthropathy, fracture, or tumor, which could influence subsequent imaging selection and interpretation.
- MRI, CT, and US are all useful in the detection and evaluation of soft-tissue infections.
- US and fluoroscopy are favored for joint aspirations, and US and CT for abscess drainage.
- Joint aspiration is recommended for evaluation of septic arthritis.
- Labeled leukocyte scan and sulfur colloid marrow scan are a useful nuclear scintigraphic combination to evaluate active infection if orthopedic hardware is present.

Summary of Evidence

Of the 41 references cited in the ACR Appropriateness Criteria® *Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)* document, all of them are categorized as diagnostic references including 1 good quality study, and 12 quality studies that may have design limitations. There are 25 references that may not be useful as primary evidence. There are 3 references that are meta-analysis studies.

The 41 references cited in the ACR Appropriateness Criteria® *Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)* document were published from 1993-2014.

While there are references that report on studies with design limitations, 1 good quality study provides 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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