

American College of Radiology ACR Appropriateness Criteria®

Clinical Condition: Bone Tumors

Variant 1: Screening, first study.

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9	Absolute requirement in patient with suspected bone lesion.	NS
US area of interest	1	Not indicated as initial study.	None
MRI area of interest	1		None
NUC bone scan targeted	1		Med
CT area of interest	1	Not indicated as initial study.	NS
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 2: Persistent symptoms, but radiograph negative.

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest	9	Contrast may be useful, depends on expertise and institutional preference.	None
NUC bone scan targeted	4	Good option if patient cannot have MRI. Non specific, MRI more specific and sensitive.	Med
CT area of interest without contrast	3	If MRI not available. Useful to evaluate cortex and trabecular pattern.	NS
US area of interest	1		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 3: Definitively benign on radiographs (Excluding Osteoid Osteoma).

Radiologic Procedure	Rating	Comments	RRL*
US area of interest	1		None
MRI area of interest	1		None
CT area of interest	1		NS
NUC bone scan targeted	1		Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

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Clinical Condition:**Bone Tumors****Variant 4:****Clinically suspected osteoid osteoma.**

Radiologic Procedure	Rating	Comments	RRL*
CT area of interest without contrast	9	Contrast not needed.	NS
X-ray area of interest	9	Necessary. Follow with CT if positive.	NS
NUC bone scan targeted	6	Very sensitive but non-specific. Good for localization if lesion is occult radiographically.	Med
MRI area of interest	6	CT is more useful but diagnosis can often be made with MRI. Contrast may improve nidus identification.	None
CT area of interest without and with contrast	2		NS
US area of interest	1		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 5:**Suspicious for malignant characteristics on radiograph.**

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest	9	Contrast can provide more information. Useful for vascularity and necrotic areas.	None
CT area of interest without and with contrast	5	May be useful if MRI not available or possible. Useful for evaluation of calcification, cortical breakthrough and pathological fractures.	NS
FDG-PET area of interest	3	Can be useful for problem solving.	High
NUC bone scan targeted	3	Probably not indicated, except to look for additional lesions.	Med
US area of interest	1		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

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BONE TUMORS

Expert Panel on Musculoskeletal Imaging: William B. Morrison, MD¹; Murray K. Dalinka, MD²; Richard H. Daffner, MD³; Arthur A. De Smet, MD⁴; George Y. El-Khoury, MD⁵; John B. Kneeland, MD⁶; B.J. Manaster, MD, PhD⁷; Helene Pavlov, MD⁸; David A. Rubin, MD⁹; Robert Schneider, MD¹⁰; Lynne S. Steinbach, MD¹¹; Barbara N. Weissman, MD¹²; Robert H. Haralson III, MD.¹³

Summary of Literature Review

There are numerous imaging techniques for evaluating bone tumors. However, the routine radiograph remains the primary screening technique and is the least expensive for detection and histologic characterization of many tumor or tumor like conditions of bone [1]. When a classically benign-appearing lesion is detected on routine radiographs, additional studies may not be required unless surgical intervention is contemplated and further anatomic information is required. In this setting either computed tomography (CT) or magnetic resonance imaging (MRI) may be most appropriate for preoperative evaluation [1-3].

When routine radiographic features are indeterminate or the lesion is more aggressive and considered to be potentially malignant, additional imaging studies are frequently required. In the past, radionuclide imaging was used to evaluate bone lesions in this setting. However, today, because of MRI's improved anatomic detail and sensitivity, it is preferred over radionuclide studies [4]. Early evaluation of MRI and CT demonstrated that MRI was superior for staging of bone tumors before treatment [1,3,5,6]. Zimmer et al [3] and Hogeboom et al [5] described MR and CT features of bone tumors with regard to cortical destruction, marrow, soft-tissue, joint and neurovascular involvement. Hogeboom et al [5] reported MRI was superior to CT for cortical bone destruction in 4.5%, for marrow involvement in 25%, for soft tissue involvement in 31%, for joint involvement in 36.4%, and for invasion of neurovascular structures in 15.3% of patients studied. In the same categories MRI and CT were felt to be equal in 63%-82% of patients. CT was superior to MRI for cortical bone destruction in 13.6% of patients and neurovascular involvement in 7.7% of patients [5]. In most institutions the choice of imaging

technique depends on patient status as well as the location and type of suspected lesion. MRI is most typically used for staging lesions in the extremities [1,3,6-8]. MR spectroscopy has potential to differentiate benign from malignant lesions, but more research is needed [9]. CT is usually preferred when tumors are located within the periosteal or cortical regions, with flat bones with thin cortex and little marrow, and to better demonstrate tumor mineralization, which may be suspected from routine radiographs [10]. For rib lesions, thin-section CT is useful to exclude benign fracture [11]. CT is also preferred over MRI for detecting a characteristic central nidus in patients with suspected osteoid osteoma on radiographs [1,2,12,13]. Positron emission tomography (PET) scanning has potential to differentiate metabolically active bone lesions from indolent ones [14,15], but this modality has mainly been used to detect metabolically active metastatic lesions or recurrences, or for preoperative evaluation of known sarcomas.

There are special considerations when dealing with suspected chondroid lesions. Intramedullary chondroid lesions appearing in the hands and feet are nearly always benign, and may present incidentally or as a pathological fracture. If the lesion is elsewhere it may be challenging by any imaging modality to differentiate a benign lesion from a low-grade malignancy. If there is pain related to the lesion, suspicion of malignancy should be high. Murphey et al [16] suggest that imaging features including deep endosteal scalloping, cortical destruction, soft tissue mass (on CT or MRI), periosteal reaction (on radiographs) and marked uptake of radionuclide can be used to distinguish appendicular enchondroma from chondrosarcoma in at least 90% of cases. Geirnaerd et al [17] suggest that radiographic signs cannot discriminate reliably between enchondroma and grade 1 chondrosarcoma, but that axial location and large size (greater than 5 cm) are the most reliable predictors of malignancy in this setting. Geirnaerd et al [18] suggest that dynamic contrast-enhanced MRI can assist in differentiating benign from malignant chondroid lesions, and Feldman et al [19] suggest that PET may be useful; however, these modalities have not been clearly established for this purpose. Protocol for follow-up of an asymptomatic, incidentally identified lesion has not been scientifically established. Authors such as Mirra's group [20] suggest that risk of malignant transformation is increased for larger lesions, lesions in the axial skeleton, and in the setting of multiple lesions (e.g., Ollier's disease) and suggest radiographic follow-up for those with higher risk but stop short of making specific recommendations regarding interval and extent of follow-up.

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Patients with symptoms related to the bone or joint with normal radiographs present a different problem. Though CT may be performed in this setting, a radionuclide bone scan may be more useful to localize the abnormality [2,12]. MRI can be very useful in this setting not only to identify whether a lesion is present but also to define the nature of a lesion based on the features discussed above; as a result, MRI is generally preferred. If an osteoid osteoma is suspected, Assoun et al [2] reported that CT was more accurate than MRI in 63% of cases. However, Liu et al [21] reported that dynamic contrast-enhanced MRI can improve conspicuity of osteoid osteoma compared to CT.

Other invasive imaging techniques, such as angiography, are not commonly required. Weatherall et al [22] compared MRI, CT, technetium-99m bone scans, and angiography for local staging of 56 patients with primary bone sarcomas. This study demonstrated that MRI was superior to CT and scintigraphy in defining the extent of bone involvement and was equal in accuracy to CT in demonstrating joint and cortical involvement. CT, MR, and angiography were compared for evaluating neurovascular involvement. CT demonstrated a sensitivity of 33%, MR 100%, and angiography 83% with specificities of 93% for CT, 98% for MR, and 71% for angiography. This study concluded that MR was the technique of choice for evaluating and staging primary bone sarcomas, including neurovascular involvement. MRI is useful for determining tissue characteristics of a bone lesion, such as fat, hemorrhage, fibrous tissue or fluid levels; with gadolinium contrast, cystic or necrotic areas can be detected [8,23-25].

Anticipated Exceptions

Routine radiographs remain the optimal screening technique. When lesions are characteristically benign, additional imaging may not be required unless needed for preoperative planning. The above data suggest that MRI is the preferred technique for staging of primary bone neoplasms but in some categories CT is equal or superior to MRI. CT is preferred for patients with suspected osteoid osteoma or subtle cortical abnormalities, and for evaluating lesion calcification or tumor matrix.

Additional exceptions for utilization of MRI include patient size and clinical status and the presence of certain metallic or electrical implants that may preclude the use of MRI.

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. 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*	Effective Dose Estimate Range
None	0
Minimal	< 0.1 mSv
Low	0.1-1 mSv
Medium	1-10 mSv
High	10-100 mSv

*RRL assignments are not included for some examinations. The RRL assignments for the NS (not specified) exams cannot be made because the RRL depends on the region of the body exposed to ionizing radiation, and the body part will vary as a function of the clinical situation.

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