

**American College of Radiology  
ACR Appropriateness Criteria®**

**Clinical Condition:** Metastatic Bone Disease

**Variant 1:** Stage 1 carcinoma of the breast. Initial presentation: asymptomatic.

Radiologic Procedure	Rating	Comments	RRL*
X-ray radiographic survey whole body	1		Med
US area of interest	1		None
INV biopsy area of interest	1		NS
X-ray myelography	1		Med
MRI area of interest	1		None
NUC Tc-99m bone scan whole body	1		Med
CT myelography spine	1		Med
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 2:** Stage 2 carcinoma of the breast. Initial presentation, with back and hip pain.

Radiologic Procedure	Rating	Comments	RRL*
X-ray spine	9		Med
NUC Tc-99m bone scan whole body	9		Med
X-ray hip	9		Med
US area of interest	1		None
NUC bone scan + SPECT hip and spine	1		Med
CT myelography spine	1		Med
CT hip and spine	1		High
X-ray radiographic survey whole body	1		Med
X-ray myelography	1		Med
MRI hip and spine	1		None
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

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**Clinical Condition:****Metastatic Bone Disease****Variant 3:****Breast carcinoma. Follow-up bone scan reveals single hot lesion in spine.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><u>RRL*</u></b>
MRI spine without contrast	9	If radiograph is negative.	None
X-ray spine hot area(s)	9		Low
MRI spine with contrast	1		None
INV core biopsy spine	1		Med
CT myelography spine	1		Med
US spine	1		None
INV fine needle aspiration spine	1		IP
X-ray radiographic survey whole body	1		Med
X-ray myelography	1		Med
CT spine	1	May be needed for biopsy localization.	Med
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 4:****Breast carcinoma. Three hot areas in spine (bone scan). No back pain.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><u>RRL*</u></b>
MRI spine without contrast	9	If radiographs are negative.	None
X-ray spine hot area(s)	9		Low
MRI spine with contrast	1		None
INV core biopsy spine	1		Med
CT myelography spine	1		Med
CT spine hot area	1	Necessary if biopsy is to be performed.	Med
INV fine needle aspiration spine	1		IP
X-ray tomography spine	1		Low
X-ray myelography	1		Med
NUC SPECT spine	1	SPECT added to bone scan in equivocal lesions.	Med
X-ray radiographic survey whole body	1		Med
US spine	1		None
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**Clinical Condition:****Metastatic Bone Disease****Variant 5:****History of treated breast carcinoma. Now has single hot lesion in sternum.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><u>RRL*</u></b>
X-ray sternum	9		Low
CT sternum	9	Important for diagnosis and for use in localization if biopsy is required.	Med
X-ray radiographic survey whole body	1		Med
X-ray tomography sternum	1		Low
US sternum	1		None
MRI sternum	1		None
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 6:****Patient with known bone metastatic disease (carcinoma of the breast). Presenting with pathological fracture of left femur on radiography.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><u>RRL*</u></b>
NUC Tc-99m bone scan whole body	9		Med
NUC femur SPECT	1		Med
X-ray radiographic survey whole body	1		Med
CT femur	1		Med
US femur	1		None
MRI femur	1		None
X-ray femur	1		Min
INV fine needle aspiration femur	1		Min
INV core biopsy femur	1		Min
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**Clinical Condition:****Metastatic Bone Disease****Variant 7:****Prostate nodule on physical exam, proven to be a well- or moderately differentiated carcinoma and PSA <20 mg/ml. Patient asymptomatic.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><a href="#">RRL*</a></b>
MRI area of interest	1		None
X-ray myelography	1		Med
CT area of interest	1		NS
US area of interest	1		None
X-ray radiographic survey whole body	1		Med
NUC Tc-99m bone scan whole body	1		Med
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 8:****Prostate nodule on physical exam, proven to be a poorly differentiated carcinoma or PSA ≥20 mg/ml. Patient asymptomatic.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><a href="#">RRL*</a></b>
NUC Tc-99m bone scan whole body	9		Med
CT area of interest	1		NS
X-ray myelography	1		Med
X-ray radiographic survey whole body	1		Med
MRI area of interest	1		None
US area of interest	1		None
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**Clinical Condition:****Metastatic Bone Disease****Variant 9:****Elderly patient with known malignancy, with back pain and partially collapsed vertebra on radiography. Otherwise healthy.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><a href="#">RRL*</a></b>
MRI spine without contrast	9	To differentiate osteoporotic collapse from destructive lesion.	None
NUC Tc-99m bone scan whole body	8	To look for other lesions and to locate biopsy location.	Med
US spine	1		None
X-ray spine	1		Med
MRI spine with contrast	1		None
CT spine	1	May be used for biopsy localization.	Med
INV core biopsy spine	1		Med
X-ray myelography	1		Med
X-ray radiographic survey whole body	1		Med
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 10:****1 cm lung nodule. Non-small cell at needle biopsy. Now coming for staging and resection.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><a href="#">RRL*</a></b>
NUC Tc-99m bone scan whole body	9		Med
US chest	1		None
MRI chest	1		None
X-ray radiographic survey whole body	1		Med
CT chest	1		Med
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

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**Clinical Condition:****Metastatic Bone Disease****Variant 11:****Patient with multiple myeloma presenting with acute low back pain.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><a href="#">RRL*</a></b>
X-ray lumbar spine	9		Med
MRI lumbar spine without contrast	8	To see characteristics of lesion and adjacent marrow.	None
X-ray radiographic survey whole body	2	Would do AP and lateral L spine rather than metastatic bone survey.	Med
X-ray myelography lumbar spine	1		Med
NUC Tc-99m bone scan whole body	1	SPECT added to bone scan in equivocal lesions. Indicated if strontium (Sr89) treatment is indicated.	Med
CT lumbar spine	1		Med
MRI lumbar spine with contrast	1		None
US lumbar spine	1		None
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 12:****Young patient with osteosarcoma of long bone coming for staging. Chest CT normal. Looking for bone metastases.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><a href="#">RRL*</a></b>
NUC Tc-99m bone scan whole body	9		Med
MRI area of interest	1		None
NUC Tc-99m bone scan with SPECT area of interest	1	SPECT added to nuclear medicine in equivocal lesions.	Med
US area of interest	1		None
CT area of interest	1		NS
X-ray radiographic survey whole body	1		Low
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**Clinical Condition:****Metastatic Bone Disease****Variant 13:****Osteosarcoma, resected clear margins. Chemotherapy, asymptomatic. Six-month follow-up after treatment to rule out bone metastases.**

Radiologic Procedure	Rating	Comments	RRL*
NUC Tc-99m bone scan whole body	9		Med
US area of interest	1		None
CT area of interest	1		NS
X-ray radiographic survey whole body	1		Med
MRI area of interest	1		None
NUC Tc-99m bone scan with SPECT area of interest	1		Med
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 14:****Elderly female with known primary, now presenting with acute vertebral collapse by radiograph and CT.**

Radiologic Procedure	Rating	Comments	RRL*
MRI spine without contrast	9		None
NUC Tc-99m bone scan whole body	9		Med
MRI spine with contrast	2		None
X-ray myelography	2		Med
X-ray radiographic survey whole body	2		Med
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 15:****Female, 8 weeks pregnant, with known primary, now suspected of having bone metastasis. She wants to continue with the pregnancy.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9		NS
MRI whole body	9		None
CT area of interest	2		NS
NUC Tc-99m bone scan whole body	2		Med
X-ray radiographic survey whole body	2		Med
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## METASTATIC BONE DISEASE

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### **Summary of Literature Review**

There are several imaging and interventional techniques for the initial detection and follow-up of metastatic bone disease: radiography, radionuclide bone scanning, computed tomography (CT), magnetic resonance imaging (MRI), fine needle aspiration, and core needle biopsy. Recently other techniques have been tested. These include 18F-fluoro-D-glucose positron emission tomography (FDG PET), 18FDG PET/CT, and whole body MRI using a rolling table platform [1-4].

Except for a few limitations, radionuclide bone scanning remains the primary imaging examination used to detect osseous metastasis. It has been repeatedly shown to be more sensitive than radiography [5]. Bone scans are sensitive in detecting osseous abnormalities, but they are nonspecific. After an abnormality has been detected, it should be radiographed to make sure it does not represent a benign process such as osteoarthritis, inflammatory arthritis or fracture [6]. One of the major advantages of radionuclide bone scanning is that it allows for a total body survey. This is important because approximately 13% of metastatic lesions occur in the appendicular skeleton in regions that are usually not included on a skeletal survey [7]. Krishnamurthy et al [7] pointed out that most metastatic skeletal lesions could be asymptomatic and that the serum alkaline phosphatase level is a poor indicator of early metastases. Highly aggressive metastases may show “cold” or photopenic areas on a bone scan [8]. Multiple myeloma can frequently show photopenic lesions or a negative bone scan [9,10]. Bone scans are also insensitive in detecting skeletal lesions due to Langerhans cell histiocytosis (histiocytosis X), and radiographic surveys are recommended for patients with this disease [11,12].

Diffuse bony metastasis may present with a pattern of intense uniform radionuclide uptake (superscan), which can be misinterpreted as a negative examination.

Solitary sites of increased radionuclide uptake in patients with known malignancy are a common occurrence, and they could pose a diagnostic problem because of the nonspecific nature of these abnormalities on bone scintigraphy. On the other hand, Boxer et al [13] reported that approximately 21% of patients with breast cancer relapsed with a solitary bone lesion, most commonly in the spine. The spine was the commonest site for both solitary and multiple metastases. Tumeh et al [14] reported that a solitary rib metastasis in cancer patients is uncommon and that 90% of hot rib lesions on bone scan are due to benign causes. A solitary sternal hot lesion in a patient with breast carcinoma has an 80% probability of being due to metastatic disease [15]. When a patient with a known primary tumor develops a solitary lesion on a bone scan, further diagnostic evaluation should be undertaken, starting with radiography and, if not diagnostic, proceeding to CT, MRI, or even biopsy [16,17]. Some authors advocate SPECT imaging as an effective method for differentiating malignant from benign lesions in the spine [18].

In stage 1 breast carcinoma where bone scintigraphy is usually negative, most authorities believe that routine baseline and follow-up bone scans are probably unwarranted because of the very low true positive yield [19,20]. The panel does not recommend any imaging studies of the skeleton in patients with stage 1 carcinoma of the breast when they present initially. Bone scanning is useful in the preoperative staging and postoperative follow-up of stages 2, 3, and 4-breast carcinoma. If a patient with stage 2 breast carcinoma presents with back and hip pain, the panel recommends radiography of the back and hip and radionuclide bone scan. Other studies may be needed depending on the results of the radiographs and bone scan. In patients with known breast carcinoma who are discovered to have a single hot area in the spine on bone scan, the panel recommends radiography of the hot area. If radiography is negative, the panel recommends MRI. For lesion localization and needle guidance, a CT scan is recommended if a needle biopsy is warranted. The panel recommends adding SPECT imaging if the planar radionuclide bone scan is equivocal. In patients discovered to have multiple hot lesions in the spine, the panel recommends radiography of the hot lesions; MRI is also recommended if the radiographic examination is negative. A CT scan becomes necessary if a needle biopsy is to be performed.

For a hot lesion of the sternum in a patient with known breast carcinoma, the panel recommends radiography,

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followed by CT, to help in the diagnosis and for localization if fine needle aspiration or core biopsy is required.

In a patient with known metastatic carcinoma presenting with a pathological fracture of a long bone on radiography, the panel recommends a radionuclide bone scan to look for other metastatic sites in the skeleton.

Recent studies have shown that for staging and follow-up of patients with prostate carcinoma, radionuclide bone scans are not necessary unless the prostate specific antigen (PSA) is greater than or equal to 20 ng/ml or the primary tumor is poorly differentiated [21-23]. For routine staging purposes (no bone pain), the panel agrees with these studies. For patients discovered to have a well- or moderately differentiated prostate carcinoma and a PSA less than 20 ng/ml, it does not recommend any imaging studies for the skeletal system. The panel, however, recommends a radionuclide bone scan for patients with a PSA greater than or equal to 20 ng/ml or a poorly differentiated primary tumor.

In patients with non-small cell carcinoma of the lung, bone is one of the most common sites for early extrathoracic spread. Some of these bony metastases could be asymptomatic. The exclusion of bone metastases is important in the initial preoperative staging of lung cancer, although it is not clear from the literature whether bone scans should be performed routinely or only when clinical indicators suggest skeletal metastases [24,25]. The panel currently recommends a radionuclide bone scan of the skeleton in patients coming for staging after needle biopsy of a lung nodule revealed a non-small cell carcinoma. However, in patients with non-small cell carcinoma of the lung who have received or will be receiving an 18FDG PET study as part of their initial work-up, a radionuclide bone scan is not necessary [1,2].

Bone metastases are very uncommon at initial presentation in patients with primary malignant bone tumors; therefore radionuclide bone scan is not indicated. Bone scanning was shown not to be useful in differentiating between benign and malignant lesions or in defining the local extent of a malignant tumor reliably [26,27]. Osteosarcoma is probably the only exception; although the yield of imaging for metastases at the time of diagnosis is small, the presence of an occasional metastasis could substantially affect the treatment of the patient [28,29]. The panel concurs with these reports, and it recommends a radionuclide bone scan for patients with osteosarcoma at presentation for staging. In patients with osteosarcoma who received adjuvant chemotherapy, 16% may develop asymptomatic osseous metastasis before lung metastasis; therefore some authors suggest bone scans for routine follow-up [28,29]. The panel concurs with these reports, and it recommends a radionuclide bone

scan for patients with osteosarcoma at follow-up and after tumor resection with clear margins and chemotherapy.

In patients with cancers that rarely metastasize to bone such as cervical, endometrial, bladder, and gastrointestinal tract tumors, baseline scans are obtained only when the disease is advanced [30]. There is no consensus in the literature about the timing of follow-up scans in asymptomatic patients. Some authors suggest a bone scan every 6 months for 1 year and then every 2 years [31]. In clinical practice, most medical and radiation oncologists request follow-up bone scans only a) in asymptomatic patients with evidence of progressive disease, (ie, rising carcinoembryonic antigen or alkaline phosphatase values), b) for restaging the disease in patients with local recurrence, and c) in patients with symptoms that are potentially of osseous origin [30].

Radiography is frequently used to screen for metastatic sites in multiple myeloma and Langerhans cell histiocytosis (histiocytosis X), but generally it is considered insensitive to screen for asymptomatic metastases [9-12]. In patients with multiple myeloma who present with acute low-back pain, the panel recommends radiographs of the lumbosacral spine or bone survey if the interval since the last bone survey is long. Most of the panel also believes that MRI is probably not indicated in this clinical situation unless the patient has neurological findings. The panel believed that the only time when radionuclide bone scan (with or without SPECT) would be needed in cases of multiple myeloma is when strontium 89 treatment is being considered.

The vertebral column deserves special consideration. It is the most common site of skeletal metastasis, and cord compression from metastasis is among the most dreaded complications of cancer [13]. MRI has proven advantages over all other imaging modalities, including myelography and CT myelography [6,17]. One limitation of MRI has been its inability to differentiate an acute traumatic or acute osteopenic compression fracture from a pathologic fracture [32]. Recently, diffusion-weighted MRI has been shown to be effective in differentiating benign osteopenic vertebral collapse from malignant collapse, but the efficacy of this technique is still controversial [33-35]. The role of 18FDG PET and 18FDG PET/CT has been assessed in metastatic disease of the spine. In patients with lung cancer, studies have shown that 18FDG has better specificity than Tc99m MDP bone scan, but similar sensitivity for detecting osseous metastatic disease [1,2]. Additionally, 18FDG PET/CT has better specificity for detecting metastatic involvement of the spine than 18FDG PET. 18FDG PET/CT allows precise localization of bone lesions and associated soft-tissue involvement with potential neurologic significance [4].

As MRI sequences continue to become faster, there is emerging evidence showing that whole-body MRI, using

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a rolling table platform, is feasible and that it can replace bone scintigraphy for detecting metastatic bone disease. Proponents of this technique indicate that whole-body MRI is more sensitive and more specific than bone scintigraphy. In addition to bone metastases, whole-body MRI can demonstrate silent metastases in the brain, lungs and liver. Whole-body MRI is also comparable in cost to bone scintigraphy [36]. No ionizing radiation is involved with whole-body MRI, making it especially suited for pregnant patients with suspected bony metastasis [3].

Depending on whether the lesion is lytic, blastic, or associated with a soft tissue mass, fine needle aspiration or core biopsy can be used to arrive at a definitive diagnosis in patients suspected of having metastasis of known or unknown origin. Needle biopsy is also helpful in suspected tumor recurrence and also to differentiate metastasis from osteonecrosis in previously irradiated bone [37-40].

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

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