Society of Nuclear Medicine Procedure Guideline for Bone Scintigraphy

version 3.0, approved June 20, 2003

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I. Purpose

The purpose of this guideline is to assist nuclear medicine practitioners in recommending, performing, interpreting, and reporting the results of bone scintigraphy.

II. Background Information and Definitions

A. Bone scintigraphy is a diagnostic study used to evaluate the distribution of active bone formation in the body.

B. Whole-body bone scintigraphy produces planar images of the skeleton, including anterior and posterior views of the axial skeleton. Anterior and/or posterior views of the appendicular skeleton also are obtained. Additional views are obtained as needed.

C. Limited bone scintigraphy records images of only a portion of the skeleton.

D. Bone single-photon emission computed tomography (SPECT) produces a tomographic image of a portion of the skeleton.

E. Multiphase bone scintigraphy usually includes blood flow images, immediate images, and delayed images. The blood flow images are a dynamic sequence of planar images of the area of greatest interest obtained as the tracer is injected. The immediate (blood pool or soft tissue phase) images include 1 or more static planar images of the areas of interest, obtained immediately after the flow portion of the study and completed within 10 min after injection of the tracer. Delayed images may be limited to the areas of interest or may include the whole body, may be planar or tomographic, and are usually acquired 2–5 h after injection. If necessary, additional delayed images may be obtained up to 24 h after tracer injection.

III. Common Indications

A. Neoplastic disease
B. Occult fracture
C. Osteomyelitis
D. Stress reaction/stress fracture
E. Avascular necrosis
F. Arthritides
G. Reflex sympathetic dystrophy
H. Bone infarcts
I. Bone graft viability
J. Otherwise unexplained bone pain
K. Distribution of osteoblastic activity before radionuclide therapy for bone pain

IV. Procedure

A. Patient Preparation
   1. The rationale for performing the procedure and the details of the procedure itself should be explained to the patient in advance. Unless contraindicated, patients should be well hydrated and instructed to drink 2 or more 8-oz glasses of water between the time of injection and the time of delayed imaging. The patient should be asked to urinate immediately before delayed imaging and to drink plenty of fluids for at least 24 h after radiopharmaceutical administration.

B. Information Pertinent to Performing the Procedure
   1. Question(s) to be answered by bone scintigraphy
   2. History of fractures, trauma, osteomyelitis, cellulitis, edema, arthritis, neoplasms, metabolic bone disease, or limitation of function
   3. Current symptoms, physical findings
   4. History of recent scintigraphy, especially with ^{131}I, ^{67}Ga, or ^{111}In

5. Results of prior bone scintigraphy
6. Results of prior imaging studies, such as conventional radiographs, computed tomography, and magnetic resonance imaging
7. History of therapy that might affect the results of bone scintigraphy (e.g., antibiotics, steroids, chemotherapy, radiation therapy, diphosphonates, or iron therapy)
8. History of orthopedic (e.g., presence and location of prosthetic implants) and nonorthopedic (e.g., ileal conduit) surgery that might affect the results of bone scintigraphy
9. Relevant laboratory results (e.g., prostate-specific antigen in patients with prostate cancer)
10. History of anatomic or functional renal abnormalities

C. Precautions
None

D. Radiopharmaceutical
Several ^{99m}Tc-labeled radiopharmaceuticals (e.g. diphosphonates) are available for bone scintigraphy. The usual administered activity for adult patients is 740–1,110 MBq (20–30 mCi) injected intravenously. For markedly obese adult patients, the administered activity may be increased to 11–13 MBq/kg (300–350 μCi/kg). For pediatric patients, the administered activity is 9–11 MBq/kg (250–300 μCi/kg), with a minimum of 20–40 MBq (.05–1.0 mCi). The maximum administered activity for pediatric patients should not exceed the administered activity for an adult.

Bone radiopharmaceuticals are subject to oxidation. Care should be taken to avoid introducing air into the multidose vial. Quality control should be performed before administration of the radiopharmaceutical (see the Society of Nuclear Medicine [SNM] *Procedure Guideline for Use of Radiopharmaceuticals).*

E. Image Acquisition
1. Flow images
If flow images are acquired, the camera should be positioned over the region of interest before tracer injection. The acquisition computer should be programmed to acquire approximately 30 frames. When digital images are acquired, blood flow images may be obtained in a $64 \times 64 \times 16$ or greater matrix at 1–3 s/frame. If film is used, 3–5 s/frame may be used.
2. Blood pool (tissue phase) images
Blood pool images should be acquired immediately after the flow portion of the study and completed within 10 min of tracer injection, for approximately 3–5 min/image. After 10 min, some activity may be apparent in the skeleton. Blood pool images are usually obtained in a $128 \times 128 \times 16$ or greater matrix, with count density of approximately 300,000 counts/image (150,000–200,000 counts/image may be adequate for extremities).
3. Delayed (skeletal phase) images
Routine delayed images are usually obtained from 2–5 h after injection.

Whole-body bone scintigraphy can be accomplished with multiple overlapping images (i.e., spot imaging) or with continuous images (i.e., whole-body scan) obtained in anterior and posterior views with a high-resolution or ultrahigh-resolution collimator. When spot views are used as the primary method of acquiring bone images, the areas of bony skeleton covered by the spot views must overlap to avoid missing regions of the skeleton.

The first spot view of the axial skeleton, usually the chest, is acquired for approxi-

Radiation Dosimetry in Adults

Radiopharmaceuticals	Administered Activity MBq (mCi)	Organ Receiving the Largest Radiation Dose* mGy/MBq (rad/mCi)	Effective Dose mSv/MBq (rem/mCi)
^{99m}Tc-phosphates and phosphonates	740–1110 (20–30) Intravenously	Bone 0.063 (0.23)	0.0080 (0.030)

*International Commission on Radiological Protection. *Radiation Dose to Patients from Radiopharmaceuticals.* ICRP report 53. London, UK: ICRP; 1988:215. Values for normal bone uptake and normal renal function. See also Medical Internal Radiation Dose Committee dose estimate report No. 13: radiation absorbed dose for ^{99m}Tc-labeled bone imaging agents. *J Nucl Med*. 1989;30:1117–1122.

Radiation Dosimetry in Children (5 Years Old)

Radiopharmaceuticals	Administered Activity MBq/kg (mCi/kg)	Organ Receiving the Largest Radiation Dose* mGy/MBq (rad/mCi)	Effective Dose mSv/MBq (rem/mCi)
^{99m}Tc-phosphates and phosphonates	9–11 (0.20–0.30) Intravenously Min: 0.50 mCi Max: 30 mCi	Bone 0.22 (0.81)	0.025 (0.093)

*International Commission on Radiological Protection. *Radiation Dose to Patients from Radiopharmaceuticals.* ICRP report 53. London, UK: ICRP; 1988:215. Values for normal bone uptake and normal renal function. See also Medical Internal Radiation Dose Committee dose estimate report No. 13: radiation absorbed dose for ^{99m}Tc-labeled bone imaging agents. *J Nucl Med.* 1989;30:1117–1122.

mately 500,000–1 million counts. The remaining spot views are then acquired for the same time as the first view. Spot images may be obtained using a $128 \times 128 \times 16$ or $256 \times 256 \times 16$ matrix. Whole-body views are usually obtained in a $256 \times 1024 \times 16$ or greater matrix.

Computer acquisition, processing, and display of images are very helpful and particularly so in pediatric populations because of extreme ranges of normal uptake. Films of scintigrams photographed with different intensities also may be helpful when digital processing and review are not available.

When whole-body scanning is used, the count rate (usually of the anterior chest) should be determined before image acquisition. The scanning speed should be adjusted so that routine delayed (obtained 2–5 h after injection) anterior or posterior whole-body images contain >1.5 million counts. If the scanner electronically joins multiple passes, care must be taken to avoid having the "zipper" superimposed on the spine.

When the probability of disseminated disease is small, a limited study is reasonable. When disseminated disease is more likely, spot views limited to the area of interest may be a source of error if distant disease is present.

4. SPECT imaging

In some patients, SPECT imaging is helpful to better characterize the presence, location, and extent of disease. SPECT imaging should be performed as recommended by the camera manufacturer. Typical acquisition and processing parameters are 360° circular orbit, 60–120 stops, $64 \times 64 \times 16$ or greater matrix, and 10–40 s/stop. An equivalent total number of counts should be acquired if continuous acquisition is used.

5. Other imaging

Additional delayed (6–24-h) images will result in a higher target-to-background ratio and may permit better evaluation of the pelvis if it was obscured by bladder activity on the routine delayed images. Six- to twenty-four-h delayed imaging may be particularly helpful in patients with renal insufficiency or urinary retention.

A pinhole collimator may be used if very high-resolution images of a specific area are necessary. Approximately 75,000–100,000 counts should be obtained for pinhole collimator views. Zoom magnification or a converging collimator also may be used to improve resolution, particularly when small structures or pediatric patients are being imaged. The physician interpreting the image should be notified when collimators that introduce distortion (e.g., a pinhole collimator) are used.

Other views (e.g., lateral, oblique, or tangential) and special views (e.g., frog-leg views of the hips or sitting-on-detector [caudal] views of the pelvis) may be obtained when necessary.

F. Interventions

The pelvis can be difficult to evaluate when there is overlying bladder activity. In patients with pelvic symptoms, 1 or more of the following additional views may better evaluate the pelvis.

1. Repeat images immediately after voiding
2. Sitting-on-detector (caudal) or oblique views
3. Lateral views
4. 24-hr–delayed images
5. SPECT acquisition. Single or multiple rapid (5–10 min/acquisition) SPECT acquisition(s) are preferred to avoid artifacts caused by changing activity in the bladder. Bladder artifacts are exaggerated in the plane in which the SPECT acquisition begins and ends. Beginning SPECT acquisition with the camera heads in the left and right lateral positions (for dual-head camera) or posterior position (for single-head camera) will help reduce bladder-filling artifact.
6. Image immediately after catheterization of the bladder. (Note: Bladder catheterization should be reserved for patients in whom visualization of the pelvis is essential.)

G. Processing

Generally no special processing of planar imaging is required. For general SPECT image processing guidelines, refer to the SNM *Procedure Guideline for General Imaging*.

H. Interpretation Criteria
   1. Increased (decreased) tracer activity in the bone compared with normal bone.
      a. Focal
      b. Diffuse
      c. Indicates increased (decreased) osteoblastic activity
      d. Differential diagnosis is long, but can be narrowed in light of:
         i. Configuration of the abnormality or abnormalities
         ii. Location and number of abnormalities
      e. Focal decrease without adjacent increase in tracer uptake is:
         i. Less common than focally increased activity
         ii. Often caused by benign conditions:
            (a)Attenuation
            (b) Artifact
            (c) Absence of bone (e.g., surgical resection)
   2. Change in focal abnormalities compared with previous study
      a. Decrease in intensity of tracer uptake and number of abnormalities:
         i. Often indicates improvement
         ii. May be secondary to focal therapy (e.g., radiation therapy)
      b. Increase in intensity of tracer uptake and in number of abnormalities may indicate:
         i. Progression of disease
         ii. Flare response to therapy
   3. Soft tissues
      a. Normal structures should be noted:
         i. Kidneys
         ii. Bladder
         iii. Generalized interstitial uptake compared with normal bone
            (a) Increased
               (1) Renal failure
               (2) Dehydration
               (3) Shortened interval between injection and imaging
            (b) Decreased
               (1) Superscan
               (2) Prolonged interval between injection and imaging
      b. Focal tracer uptake
      c. Diffuse tracer uptake
   4. Bone scans are very sensitive for disease, but specificity of findings is low and must be interpreted in light of other information
      a. History
      b. Physical exam
      c. Other test results
      d. Comparison with previous studies

I. Reporting
   1. Description of technique
      a. Flow images
      b. Blood pool images
      c. Delayed images
      d. Injection site
      e. SPECT (if applicable)
   2. Description of abnormal tracer uptake
      a. Increased
      b. Decreased
      c. Pattern of abnormal uptake
      d. Bone findings
      e. Soft tissue findings
   3. Correlation with other studies
   4. Comparison with previous studies
   5. Interpretation
      a. Narrow differential as much as possible
      b. Recommend further, more definitive study(ies), if differential diagnosis is broad

J. Quality Control

See the SNM *Procedure Guideline for General Imaging*.

K. Sources of Error
   1. Urine contamination or a urinary diversion reservoir
   2. Injection artifacts
   3. Prosthetic implants, radiographic contrast materials, or other attenuating artifacts that might obscure normal structures
   4. Homogeneously increased bony activity (e.g., “superscan”)
   5. Patient motion

6. Greater than necessary collimator-to-patient distance
7. Imaging too soon after injection, before the radiopharmaceutical has been optimally cleared from the soft tissues
8. Restraint artifacts caused by soft-tissue compression
9. Prior administration of a higher energy radionuclide (^{131}I, ^{67}Ga, ^{111}In) or of a ^{99m}Tc radiopharmaceutical that accumulates in an organ that could obscure or confound the skeletal activity
10. Radioactivity extraneous to the patient
11. Significant findings outside the area of interest that may be missed if a limited study is performed
12. Radiopharmaceutical degradation
13. Changing bladder activity during SPECT of pelvic region
14. Purely lytic lesions
15. Pubic lesions obscured by underlying bladder activity
16. Renal failure

V. Issues Requiring Further Clarification

None

VI. Concise Bibliography

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VII. Disclaimer

The Society of Nuclear Medicine has written and approved guidelines to promote the cost-effective use of high-quality nuclear medicine procedures. These generic recommendations cannot be applied to all patients in all practice settings. The guidelines should not be deemed inclusive of all proper procedures or exclusive of other procedures reasonably directed to obtaining the same results. The spectrum of patients seen in a specialized practice setting may be quite different from the spectrum of patients seen in a more general practice setting. The appropriateness of a procedure will depend in part on the prevalence of disease in the patient population. In addition, the resources available to care for patients may vary greatly from one medical facility to another. For these reasons, guidelines cannot be rigidly applied.

Advances in medicine occur at a rapid rate. The date of a guideline should always be considered in determining its current applicability.