Society of Nuclear Medicine Procedure Guideline for Bone Scintigraphy
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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 imaging study which records the distribution of a radioactive tracer in the skeletal system in planar (two-dimensional) and/or tomographic (three-dimensional) images.
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 are also obtained. Additional views are obtained as needed.
C. Limited bone scintigraphy records images of only a portion of the skeleton.
D. Bone SPECT (single photon emission computed tomography) produces a tomographic image of a portion of the skeleton.
E. Multiphase bone scintigraphy usually consists of blood flow images, immediate images and delayed images. The blood flow images consist of a dynamic sequence of planar images of the area of greatest interest obtained as the tracer is injected. The immediate (blood pool) images consist of one or more static planar images of the areas of interest, obtained 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 to 5 hr after injection. Further additional delayed images obtained up to 24 hr following tracer injection may be obtained if necessary.

III. Common Indications
A. Neoplastic disease
B. Occult fracture
C. Osteomyelitis
D. Avascular necrosis
E. Arthritides
F. Reflex sympathetic dystrophy
G. Bone infarcts
H. Bone graft viability
I. Otherwise unexplained bone pain
J. Distribution of osteoblastic activity prior to Sr-89 therapy

IV. Procedure
A. Patient Preparation
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 two 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 prior to delayed imaging and to drink plenty of fluids for at least 24 hr 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 I-131, Ga-67 and In-111
5. Results of prior bone scintigraphy
6. Results of prior imaging studies such as conventional radiographs, CT and MRI
7. History of therapy that might affect the results of bone scintigraphy (e.g. antibiotics, steroids, chemotherapy, radiation therapy, diphosphonates, iron therapy)
8. History of orthopedic (e.g. presence and location of prosthetic implants) and nonorthopedic surgery (e.g. ileal conduit) that might affect the results of bone scintigraphy
9. Relevant laboratory results (e.g. PSA in patients with prostate cancer)
10. History of anatomic or functional renal abnormalities

C. Precautions
1. Elective bone scintigraphy should be deferred in pregnant women if possible.
2. When possible, breastfeeding should be discontinued for 24 hr after radiopharmaceutical injection.

D. Radiopharmaceutical
Several Tc-99m labeled radiopharmaceuticals (e.g. diphosphonates or pyrophosphates) are available for bone scintigraphy. The usual administered activity for adult patients is 740 to 1110 MBq (20 to 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 40–90 MBq (1.0–2.5 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 prior to administration of the radiopharmaceutical (see the Society of Nuclear Medicine Procedure Guideline for Use of Radiopharmaceuticals).

E. Image Acquisition
If flow images are done, the camera should be positioned over the region of interest prior to injecting the tracer. The acquisition computer should be programmed to acquire approximately 30 frames for approximately 1–2 sec per frame. If film is used, 3–5 sec per frame may be

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### Radiation Dosimetry for Adults

<table>
<thead>
<tr>
<th>Radiopharmaceuticals</th>
<th>Administered Activity MBq (mCi)</th>
<th>Organ Receiving the Largest Radiation Dose* mGy (rad)</th>
<th>Effective Dose* mSv (rem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tc-99m phosphates and phosphonates</td>
<td>740 – 1110 i.v. (20 – 30)</td>
<td>0.063 Bone (0.23)</td>
<td>0.0080 (0.030)</td>
</tr>
</tbody>
</table>

\*per MBq (per mCi)

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### Radiation Dosimetry for Children

<table>
<thead>
<tr>
<th>Radiopharmaceuticals</th>
<th>Administered Activity MBq/kg (mCi/kg)</th>
<th>Organ Receiving the Largest Radiation Dose* mGy (rad)</th>
<th>Effective Dose* mSv (rem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tc-99m phosphates and phosphonates</td>
<td>9 – 11 i.v. (0.25 – 0.30)</td>
<td>0.22 Bone (0.81)</td>
<td>0.025 (0.093)</td>
</tr>
</tbody>
</table>

\*per MBq (per mCi)
used. The acquisition should be started just as the tracer is injected. Blood-pool images should be acquired within 10 min of tracer injection for approximately 3–5 min per image. After 10 min, some activity may be apparent in the skeleton.

When digital images are acquired, blood flow images may be obtained in 64 x 64 x 16 or greater matrix at 1 to 3 sec per frame. Blood-pool images are usually obtained in 128 x 128 x 16 or greater matrix with count density of approximately 300,000 counts/image (150,000–200,000 counts from 2–5 hr after injection. Additional delayed imaging may be adequate for extremities).

Routine delayed images are usually obtained from 2–5 hr after injection. Additional delayed (6–24 hr) 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 24-hr delayed imaging may be particularly helpful in patients with renal insufficiency and patients with urinary retention.

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. 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 approximately 500,000 to 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 x 128 x 16 or a 256 x 256 x 16 matrix. Whole-body views are usually obtained in 256 x 1024 x 16 or greater matrix.

Computer acquisition, processing and display of images may be particularly helpful in pediatric populations because of extreme ranges of normal uptake. Films of scintigrams photographed with different intensities may also be helpful if 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 (obtained 2–5 hr after injection) delayed 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.

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 x 64 x 16 or greater matrix, and 10–40 sec/stop. An equivalent total number of counts should be acquired if continuous acquisition is used.

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 may also 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, such as a pinhole collimator, are used.

Other views, such as lateral, oblique or tangential, and special views such as frog-leg views of the hips or sitting-on-detector (caudal) views of the pelvis are obtained, when necessary.

F. Interventions
The pelvis can be difficult to evaluate when there is overlying bladder activity. In patients with pelvic symptoms, one 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 per acquisition) SPECT acquisition(s) are preferred to avoid artifacts caused by changing activity in the bladder. Bladder artifacts are exaggerated in the plane where the SPECT acquisition begins and ends.
6. Image immediately following 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 Society of Nuclear Medicine Procedure Guideline for General Imaging.

H. Interpretation Criteria
1. Increased (decreased) tracer activity in the bone compared to 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
   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 to
   previous study
   a. Decrease in intensity of tracer uptake and in
      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
      i. Progression of disease
      ii. Flare response to therapy

3. Abnormalities should be interpreted with
   other available information
   a. History
   b. Physical exam
   c. Other imaging studies
   d. Laboratory tests

4. Soft tissues
   a. Normal structures should be noted
      i. Kidneys
      ii. Bladder
      iii. Generalized interstitial uptake compared to 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

5. 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 Society of Nuclear Medicine 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 which 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 (I-131, Ga-67, In-111), or of a Tc-99m 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 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


Pomeranz SJ, Pretorius HT, Ramsingh PS. Bone scintigraphy and multimodality imaging in bone neoplasia: strategies for imaging in the new health care cli-

VIII. 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 than 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.