ACR–ACNM–SNMMI–SPR PRACTICE PARAMETER FOR THE PERFORMANCE OF SKELETAL SCINTIGRAPHY (BONE SCAN)

PREAMBLE

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care[1]. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the practitioner considering all the circumstances presented. Thus, an approach that differs from the guidance in this document, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in this document when, in the reasonable judgment of the practitioner, such course of action is indicated by variables such as the condition of the patient, limitations of available resources, or advances in knowledge or technology after publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document may consider documenting in the patient record information sufficient to explain the approach taken.

The practice of medicine involves the science, and the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to the guidance in this document will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The purpose of this document is to assist practitioners in achieving this objective.

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1 *Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, 831 N.W.2d 826 (Iowa 2013) Iowa Supreme Court refuses to find that the "ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures (Revised 2008)" sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, Stanley v. McCarver, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.*

I. INTRODUCTION

This practice parameter has been revised collaboratively by the American College of Radiology (ACR), the American College of Nuclear Medicine (ACNM), the Society of Nuclear Medicine and Molecular Imaging (SNMMI), and the Society for Pediatric Radiology (SPR).

The aim of this practice parameter is to guide physicians performing skeletal scintigraphy in adult and pediatric patients. Skeletal scintigraphy involves the intravenous injection of a bone-seeking technetium-99m (Tc-99m) diphosphonate radiopharmaceutical or fluorine-18 (F-18) sodium fluoride with imaging using a gamma camera or

PET system.

Skeletal scintigraphy is a sensitive method for detecting a variety of anatomic and physiologic abnormalities of the musculoskeletal system. Although certain patterns are suggestive of specific disease entities, correlation of abnormal findings with clinical information, radiographs, computed tomography (CT), magnetic resonance imaging (MRI), and other scintigraphic examinations is frequently helpful for diagnosis.

Application of this practice parameter should be in accordance with the ACR-ACNM-SNMMI-SPR Practice Parameter for the Use of Radiopharmaceuticals in Diagnostic Procedures [1].

The goal of skeletal scintigraphy is to enable the interpreting physician to detect pathophysiologic abnormalities of the musculoskeletal system.

II. INDICATIONS

Clinical indications for skeletal scintigraphy include, but are not limited to, detection, evaluation, and/or follow-up of [2]:

1. Metastatic osteoblastic bone neoplasms
2. Primary benign and malignant bone neoplasms
3. Fractures: stress, occult, accidental, and nonaccidental
4. Pain of suspected musculoskeletal etiology or abnormal radiographic, laboratory, or clinical findings that suggest skeletal involvement
5. Musculoskeletal inflammation and infection
6. Metabolic bone disease
7. Tumor-like conditions such as Paget disease, Langerhans cell histiocytosis, and fibrous dysplasia
8. Arthritides
9. Bone viability (grafts, infarcts, osteonecrosis)
10. Orthopedic hardware/prosthetic joint complications
11. Heterotopic ossification/soft-tissue calcification
12. Complex regional pain syndrome (CRPS)/reflex sympathetic dystrophy (RSD)
13. Distribution of osteoblastic activity prior to therapeutic radiopharmaceutical administration for palliation of bone pain
14. Congenital or developmental anomalies

The ACR–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Patients with Ionizing Radiation provides useful information on radiation risks to the fetus regardless of source. Information on managing pregnant or potentially pregnant patients undergoing nuclear medicine procedures is available from the International Commission on Radiological Protection [3-5].

III. QUALIFICATIONS AND RESPONSIBILITIES

See the ACR-ACNM-SNMMI-SPR Practice Parameter for the Use of Radiopharmaceuticals in Diagnostic Procedures [1].

IV. SPECIFICATIONS AND PERFORMANCE OF THE EXAMINATION

The written or electronic request for skeletal scintigraphy should provide sufficient information to demonstrate the medical necessity of the examination and allow for its proper performance and interpretation.

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). Additional information regarding the specific reason for the examination or a provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the examination.

The request for the examination must be originated by a physician or other appropriately licensed health care provider. The accompanying clinical information should be provided by a physician or other appropriately licensed health care provider familiar with the patient's clinical problem or question and consistent with the state's scope of practice requirements. (ACR Resolution 35 adopted in 2006 – revised in 2016, Resolution 12-b)

IV. SPECIFICATIONS AND PERFORMANCE OF THE EXAMINATION

A. Radiopharmaceuticals

1. Tc-99m medronate (methylene diphosphonate [MDP]), Tc-99m oxidronate (hydroxymethylene diphosphonate [HDP]), or a comparable radiopharmaceutical is administered intravenously. The usual administered activity for adults is 555 to 1,110 MBq (15–30 mCi). It is desirable to use the lowest administered activity possible to obtain diagnostically accurate images. As a consideration, 2 large surveys based upon data from the Intersocietal Accreditation Commission (IAC) and the ACR accreditation data have both reported achievable administered activities (AAAs) and diagnostic reference levels (DRLs) of 25 mCi and 27 mCi, respectively. AAAs are set at the median (50th percentile) of the dose administered and are intended to identify common practice. DRLs are set at the 75th percentile of radiation doses and may help identify unusually high doses [6,7].

   Administered activity for children and adolescents should be determined based on body weight and should be as low as reasonably achievable (ALARA) for diagnostic image quality. Generally, the administered activity for children and adolescents is 9.3 MBq/kg (0.25 mCi/kg), with a minimum administered activity of 37 MBq (1 mCi). Tc-99m diphosphonates are susceptible to oxidation; introduction of air during kit formulation may result in radiopharmaceutical breakdown and imaging artifacts secondary to free pertechnetate.

2. F-18 sodium fluoride is administered intravenously. The usual administered activity for adults is 185 to 370 MBq (5–10 mCi). For adults with obesity, 370 MBq (10 mCi) may be administered. The administered activity for children and adolescents should be weight based (2.22 MBq/kg [0.06 mCi/kg]) and should be ALARA for diagnostic image quality. The minimum administered activity is 18.5 MBq (0.5 mCi), with a range of 18.5 to 185 MBq (0.5–5 mCi).

IV. SPECIFICATIONS AND PERFORMANCE OF THE EXAMINATION

B. Patient Factors

The patient should be instructed to arrive for the examination well hydrated unless clinically contraindicated. To improve the target-to-background ratio, ingestion of liquids should be further encouraged between the time of radiopharmaceutical injection and imaging. Frequent voiding should be encouraged to decrease the radiation dose to the urinary bladder (critical organ).

The bladder should be emptied immediately prior to imaging. If, while imaging, the bladder fills and limits evaluation of the bony pelvis, further voiding followed by repeat imaging should be performed. If the bladder obscures portions of the pelvis despite attempts to void, oblique views, tail-on-detector (TOD) views, delayed imaging, single-photon emission CT (SPECT) imaging, or bladder catheterization may be helpful.

The physician and technologist should be alert to the possibility of hot artifacts, such as urine contamination, an intravenous access site, and extravasation at the site of injection. Cold artifacts may be produced by antecedent barium administration or certain external items; belt buckles, jewelry, and other metallic objects should be removed before imaging when practical.

Sedation should be considered in uncooperative patients. Infants can often be adequately immobilized by swaddling. Feeding an infant prior to imaging can be used to induce sleep and facilitate imaging.

IV. SPECIFICATIONS AND PERFORMANCE OF THE EXAMINATION

C. Images

1. Gamma Camera Imaging
   a. Three-phase scintigraphy: initial blood flow images (1–5 seconds per frame for 30–60 seconds), blood pool imaging (up to 10 minutes postinjection), and delayed static imaging (up to 24 hours) of a

specific part of the skeleton may be useful. Indications include, but are not limited to, infection, CRPS, trauma, neoplasm, and heterotopic ossification. In the pediatric age group or for adults with nonlocalized bone pain or joint pain (synovitis), whole-body blood pool imaging may be helpful.

b. For routine delayed skeletal scintigraphy, imaging should commence 2 to 4 hours after radiopharmaceutical administration. To improve image quality for patients in whom soft-tissue clearance is impaired, additional delayed imaging may be performed up to 24 hours.
    i. Images of the skeleton appropriate to the clinical history and symptoms should be obtained. For examinations of the entire skeleton, anterior and posterior whole-body images of the entire axial and appendicular skeleton are standard.
        - If limited images of the appendicular skeleton are acquired, carefully positioned comparison views of the contralateral side should be obtained. If both cannot be included within the same field of view (FOV), the unaffected side should be acquired first and the affected side imaged for the same amount of time. Right and left labeling should be annotated on the images. If a radioactive marker is placed, it is standard to mark the right side of the body.
    ii. Whole-body images may be supplemented by "spot" lateral images of the skull, lateral images of the extremities, oblique images of the torso, pinhole images, and/or SPECT or SPECT/CT images of specific regions of interest.
    iii. Pinhole, SPECT, or SPECT/CT may be of particular benefit in patients with unexplained back pain or for better characterization of lesions detected on planar images.
    iv. For examinations of the entire skeleton, multiple spot images or whole-body images may be obtained. Anterior and posterior images of the axial and appendicular skeleton are standard.

c. SPECT imaging improves contrast resolution, scan sensitivity, and specificity; provides more precise localization of the radiopharmaceutical; and improves visualization of subtle abnormalities.

d. Hybrid SPECT/CT imaging, which provides the best anatomic localization of scintigraphic findings, can further improve scan sensitivity and specificity.

e. Software image fusion of SPECT with CT and/or MRI can result in improved localization and correlation of scintigraphic findings.

2. PET/CT and PET/MR Imaging

a. Emission images of the axial skeleton with F-18 sodium fluoride can be obtained as early as 30 to 45 minutes postadministration of the radiopharmaceutical; in patients in renal failure, a longer delay may be necessary. Images of the extremities, either as part of whole-body imaging or limited to the extremities, should be obtained 90 to 120 minutes postadministration of the radiopharmaceutical. Acquisition time per bed position will vary depending on several factors, including administered activity, time postinjection, body habitus, and system characteristics, but typical acquisition times are 2 to 5 minutes per bed position. There appears to be increased sensitivity using F-18 sodium fluoride compared with planar Tc-99m diphosphonate bone scintigraphy [8].

b. Corresponding CT or MR imaging as part of hybrid PET cameras is useful for attenuation correction of emission images and improves both specificity and anatomic localization of scintigraphic findings. Dose parameters of CT should be consistent with the principles of ALARA.

V. EQUIPMENT SPECIFICATIONS

Equipment performance monitoring should be in accordance with the ACR–AAPM Technical Standard for Nuclear Medical Physics Performance Monitoring of Gamma Cameras and the ACR–AAPM Technical Standard for Medical Physics Performance Monitoring of PET/CT Imaging Equipment [11,12].

V. EQUIPMENT SPECIFICATIONS

A. Planar Gamma Camera Imaging

For standard FOV gamma cameras, low-energy high-resolution or ultra-high-resolution collimators should be used. Although the information content of the images improves in proportion to the number of counts collected per image, information density must be balanced against patient comfort/motion and practical time constraints. Resolution recovery postprocessing may allow imaging time or administered activity to be reduced. Suggested counts are:

1. Axial skeleton: 500,000 counts per image
2. Appendicular skeleton: 100,000 to 300,000 counts per image
3. Whole-body: 1,000,000 counts each for both the anterior and posterior views. The suggested scan speed for a blood pool whole-body image is 40 cm/min or, for static images, 5 to 10 min/image. The suggested scan speed for a whole-body delayed image is 10 cm/min (8–15 cm/min depending on patient size) or 10 min/image.

For large FOV gamma cameras, larger crystal size makes greater count rates available for a given administered activity. Although the trade-offs between improved image quality, patient comfort/motion, and practical imaging times are the same as for standard FOV cameras, the greater efficiency of large FOV cameras permits better detail and higher information content through the use of a high-resolution collimator and increased counting statistics. Suggested minimum counts are:

1. Axial skeleton: 600,000 counts per image
2. Appendicular skeleton: 150,000 to 400,000 counts per image
3. Whole-body scan: 1,500,000 to 2,000,000 counts each for both the anterior and posterior views. The suggested scan speed for a blood pool whole-body image is 40 cm/min or, for static images, 5 to 10 minutes/image. The suggested scan speed for a whole-body delayed image is 10 cm/min (8–15 cm/min, depending on patient size) or 10 min/image.

- A planar “spot” imaging protocol, wherein multiple overlapping anterior and posterior images of the whole-body are acquired in lieu of a continuous whole-body scan, can be used for young nonsedated patients.
- When examining infants or small children who have received low radiopharmaceutical administered activity, case-by-case adjustment is advised to achieve the highest attainable count density with the fewest possible motion artifacts.
- Pinhole images of the hips are typically acquired using a 3- to 4-mm pinhole collimator insert at 10 to 15 minutes per image. Pinhole images of the hands and feet can also be used instead of zoomed static images and may be acquired in less time.
- The bladder may be shielded if full. Pinhole images of the hands and feet can also be used instead of zoomed static images and may be acquired in less time.

V. EQUIPMENT SPECIFICATIONS

B. SPECT and SPECT/CT Imaging

SPECT or the SPECT portion of a SPECT/CT examination should be performed using a high-resolution or ultra-high-resolution collimator, a 360° orbit, at least a 128 × 128 matrix, and at least 120 projections (3 degree intervals). The 120 projections can be obtained from 60 positions with a dual-detector camera and 40 positions with a triple-detector camera. Each projection is collected for 15 to 40 seconds (typically 20–30 seconds). For a single-detector camera, a low-energy, all-purpose collimator may be used with shorter acquisition time per projection in order to limit overall imaging time.

Even relatively little patient motion considerably degrades SPECT image quality. Improved statistical quality of the data with longer acquisition times needs to be balanced against increased patient motion.

For bone imaging, CT exposure parameters can be reduced from those used for diagnostic CT imaging, although soft-tissue detail may be degraded. Appropriate pediatric-specific CT exposure parameters should be used when applicable, with CT imaging limited to the area of SPECT/clinical concern when possible [9,10].

Iterative reconstruction is preferred over filtered back projection. Reconstruction methods that use resolution recovery postprocessing may allow imaging time or administered activity to be reduced.

V. EQUIPMENT SPECIFICATIONS

C. PET/CT and PET/MR Imaging

The PET portion of the examination is performed with the acquisition of whole-body images, from the head to the feet, usually in 3-D mode with at least a 128 × 128 matrix. The number of bed positions varies, with acquisition of 2 to 5 minutes per bed position.

As with SPECT, patient motion degrades images.

Iterative reconstruction, such as ordered-subset expectation maximization, is preferred. Reconstruction methods that utilize time-of-flight PET and resolution recovery are encouraged.

Equipment performance monitoring should be in accordance with the ACR–AAPM Technical Standard for Nuclear Medical Physics Performance Monitoring of Gamma Cameras and the ACR–AAPM Technical Standard for Medical Physics Performance Monitoring of PET/CT Imaging Equipment [11,12].

VI. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [13].
The report should include the radiopharmaceutical**,** dosage, and route of administration as well as any other pharmaceuticals administered, including the dosage and route of administration.

VII. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, non-physician radiology providers**,** radiologic technologists, and all supervising physicians have a responsibility for safety in the workplace by keeping radiation exposure to staff, and to society as a whole, "as low as reasonably achievable" (ALARA) and to assure that radiation doses to individual patients are appropriate, taking into account the possible risk from radiation exposure and the diagnostic image quality necessary to achieve the clinical objective. All personnel who work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection, application of dose constraints and limits) and the principles of proper management of radiation dose to patients (justification, optimization including the use of dose reference levels). https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1775_web.pdf
Facilities and their responsible staff should consult with the radiation safety officer to ensure that there are policies and procedures for the safe handling and administration of radiopharmaceuticals in accordance with ALARA principles. These policies and procedures must comply with all applicable radiation safety regulations and conditions of licensure imposed by the Nuclear Regulatory Commission (NRC) and by applicable state, local, or other relevant regulatory agencies and accrediting bodies, as appropriate. Quantities of radiopharmaceuticals should be tailored to the individual patient by prescription or protocol, using body habitus or other customized method when such guidance is available.
Nationally developed guidelines, such as the ACR's Appropriateness Criteria®, should be used to help choose the most appropriate imaging procedures to prevent unnecessary radiation exposure.
Additional information regarding patient radiation safety in imaging is available from the following websites – Image Gently® for children (www.imagegently.org) and Image Wisely® for adults (www.imagewisely.org). These advocacy and awareness campaigns provide free educational materials for all stakeholders involved in imaging (patients, technologists, referring providers, medical physicists, and radiologists).
Radiation exposures or other dose indices should be periodically measured by a Qualified Medical Physicist in accordance with the applicable ACR Technical Standards. Monitoring or regular review of dose indices from patient imaging should be performed by comparing the facility's dose information with national benchmarks, such as the ACR Dose Index Registry and relevant publications relying on its data, applicable ACR Practice Parameters, NCRP Report No. 172, Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States or the Conference of Radiation Control Program Director's National Evaluation of X-ray Trends; 2006, 2009, amended 2013, revised 2023 (Res. 2d).

Table 1. Patient Radiation Dosimetry Tc-99m-Labeled Phosphonates [14]:

Patient	Organs receiving the largest radiation dose	Effective dose
Adult	Bone surfaces 0.063 mGy/MBq (0.23 rad/mCi) Bladder 0.048 mGy/MBq (0.18 rad/mCi)	0.0057 mSv/MBq (0.021 rem/mCi)
15-year-old	Bone surfaces	0.007 mSv/MBq (0.026 rem/mCi)

	0.082 mGy/MBq (0.30 rad/mCi) Bladder 0.060 mGy/MBq (0.22 rad/mCi)	
10-year-old	Bone surfaces 0.13 mGy/MBq (0.48 rad/mCi) Bladder 0.080 mGy/MBq (0.3 rad/mCi)	0.011 mSv/MBq (0.041 rem/mCi)
5-year-old	Bone surfaces 0.22 mGy/MBq (0.81 rad/mCi) Bladder 0.073 mGy/MBq (0.27 rad/mCi)	0.014 mSv/MBq (0.052 rem/mCi)
1-year-old	Bone surfaces 0.53 mGy/MBq (2.0 rad/mCi) Bladder 0.13 mGy/MBq (0.48 rad/mCi)	0.027 mSv/MBq (0.10 rem/mCi)

Table 2. Patient Radiation Dosimetry F-18 sodium fluoride [15]:		
Patient	Organs receiving the largest radiation dose	Effective dose
Adult	Bladder 0.15 mGy/MBq (0.56 rad/mCi) Bone surfaces 0.094 mGy/MBq (0.35 rad/mCi)	0.017 mSv/MBq (0.063 rem/mCi)
15-year-old	Bladder 0.19 mGy/MBq (0.7 rad/mCi) Bone surfaces 0.075 mGy/MBq (0.28 rad/mCi)	0.02 mSv/MBq (0.074 rem/mCi)
10-year-old	Bladder 0.28 mGy/MBq (1 rad/mCi) Bone surfaces 0.12 mGy/MBq (0.44 rad/mCi)	0.033 mSv/MBq (0.12 rem/mCi)
5-year-old	Bladder 0.39 mGy/MBq (1.4 rad/mCi) Bone surfaces 0.21 mGy/MBq (0.78 rad/mCi)	0.056 mSv/MBq (0.21 rem/mCi)
1-year-old	Bladder 0.54 mGy/MBq (2.0 rad/mCi) Bone surfaces 0.48 mGy/MBq (1.8 rad/mCi)	0.11 mSv/MBq (0.41 rem/mCi)

VIII. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading *ACR Position Statement on Quality Control & Improvement, Safety, Infection Control*, *and Patient Education* on the ACR website (https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Quality-Control-and-Improvement).

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*Practice parameters and technical standards are published annually with an effective date of October 1 in the year in which amended, revised or approved by the ACR Council. For practice parameters and technical standards published before 1999, the effective date was January 1 following the year in which the practice parameter or technical standard was amended, revised, or approved by the ACR Council.

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