

Nonosseous Abnormalities on Bone Scans*

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Although bone scanning is a test primarily concerned with skeletal abnormalities, important nonosseous findings are occasionally present on the images. To gauge the significance of such nonosseous uptake and, in particular, to determine whether these findings contain useful diagnostic information, the technical and medical staff in nuclear medicine must recognize the various patterns of nonbony uptake and understand their causes. The objectives of this article are to demonstrate the appearances of nonosseous uptake on bone scans, to categorize the forms of soft-tissue uptake, to emphasize technical artifacts leading to soft-tissue uptake, and to highlight the clinical significance of pathologic soft-tissue uptake.

Key Words: bone scintigraphy; breast cancer; renal cell carcinoma; malignant pleural effusion

J Nucl Med Technol 2003; 31:149–153

Bone scanning using the ^{99m}Tc -phosphate analogs is an established diagnostic modality for a variety of pathologies involving the skeleton, such as osteomyelitis, bony metastases, and occult fractures. Technically, scanning is performed using different imaging protocols depending on the indication for the scan. For instance, multiphase bone scanning is performed to image osteomyelitis; whole-body imaging, to image metastatic bone disease; and SPECT, to localize abnormalities in 3 dimensions for spine or hip lesions. The appearance of both skeletal and soft-tissue uptake depends heavily on imaging technique, and the practitioner should be aware of the impact of technical factors on image quality (1,2). The bone scan is interpreted by evaluating the pattern of radioactive localization in the bones and identifying areas of increased uptake (hot spots) or, less frequently, decreased or absent skeletal uptake. In addition, allowance is made for the normal uptake in the kidneys and urinary tract due to excretion of the radiopharmaceutical with subsequent drainage into the urine. Renal

function and metabolic status of the patient also strongly affect the scan appearance of both skeletal and soft-tissue uptake (3).

In certain conditions, nonosseous structures other than the urinary tract are seen on the bone scan. For example, there may be localized muscle uptake, such as myositis ossificans, or localization in a pleural effusion. Such serendipitous findings may constitute welcome diagnostic information. On the other hand, soft-tissue uptake may at times hamper interpretation of the study by bringing in artifacts that degrade the quality of the images. Therefore, recognition of patterns of nonbony uptake is important for correct identification of artifacts and accurate interpretation of the scan.

In this article, an examination of nonosseous abnormalities on bone scans is presented. The review is based on the authors' own experience and on a summary of the medical literature. Soft-tissue abnormalities are divided into 3 classifications: technical artifacts, urinary tract findings, and uptake in other soft tissues or viscera.

TECHNICAL ARTIFACTS

Artifacts related to poor technique are commonly observed on bone scans. Recognition of these "abnormalities" will lead in most cases to rectification of the error and, thereafter, acquisition of the appropriate study. Technical artifacts can be divided further into those related to the radiopharmaceutical, injection technique, or imaging process.

Radiopharmaceutical

A faulty radiopharmaceutical preparation can lead to altered biodistribution of ^{99m}Tc -methylene diphosphonate (MDP), markedly affecting the diagnostic image (4). Additional structures not usually seen on the scan will be identified, such as gastric uptake due to free ^{99m}Tc -pertechnetate (5). Faulty preparation such as occurs when aluminum ions are present (6), when dextrose solutions are added (7), when a preparation is left unused for a long time (8), or when an inappropriately high pH is present in the reaction mixture (9) will result in unintended soft-tissue uptake. The uptake of radioactivity in bone may be affected to such an extent that interpretation of the scan becomes impossible. Other situations leading to uninterpretable bone scans will be encountered in patients on medications that alter the distri-

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TABLE 1
Effects of Faulty Radiopharmaceutical Preparation on Bone Scan

Fault	Effect on bone scan
Free pertechnetate due to presence of air in container, a long-standing preparation, an inappropriate amount of stannous ion, or altered preparation	Thyroid uptake on early images (blood pool) and stomach, gastrointestinal tract, and salivary gland uptake
Colloid formation due to aluminum	Diffuse liver uptake and reduced bone uptake
High pH in the preparation	Liver, gallbladder, and gastrointestinal tract uptake
Drug interaction:	
Diphosphonates, etidronate	Decreased bone uptake
Iron	Increased soft-tissue uptake; renal cortex uptake
Chemotherapy	Renal cortex uptake and diffuse skull uptake

bution of the ^{99m}Tc -phosphate compound; for example, the diphosphonates used for treatment of osteoporosis saturate the sites of ^{99m}Tc -MDP uptake on bone (10). To avoid such drastic concerns, one should check the patient's medications for possible interaction with the radiotracer. In addition, special therapies or interventions should be recorded in relationship to the scan to clarify some unexpected findings on the images, such as renal cortical uptake due to iron overload or after chemotherapy (11,12). In Table 1, the effects on the bone scan of various radiopharmaceutical contaminants or drug interactions are listed.

Injection Technique

Rarely, extravasation at the site of injection of ^{99m}Tc -MDP may be confused with an abnormality on the bone scan: Marking injection sites will prevent such confusion. The pressure and motion generated during bolus intravenous injection can easily dislodge the needle from the vein, causing extravasation of the radioactivity into the surrounding soft tissue. For this reason, faulty intravenous injection is the most frequent cause of abnormal soft-tissue uptake on bone scans (13). Another much less frequent blunder due to a faulty injection technique is arterial puncture and intraarterial injection of the radiotracer (14). After intraarterial injection, the distal arterial distribution shows pronounced soft-tissue uptake. For example, injection of ^{99m}Tc -MDP into the radial artery produces dramatic uptake over the lateral side of the hand and wrist (Fig. 1).

Imaging Process

Despite routine quality control testing, artifacts due to equipment failure or faulty technique remain unfortunately common (15). Equipment malfunction such as a camera badly out of tune or the use of the wrong flood correction map will produce a nonuniform appearance that simulates soft-tissue uptake. However, the most frequently encountered problem is patient motion, which at times can produce blurred structures on the image similar to soft-tissue uptake. Motion artifacts are particularly serious in SPECT reconstruction; therefore, routinely checking the raw projection data before discharge of the patient is important. Furthermore, when not adequately supervised, the patient may place an upper limb over the site that is being imaged,

leading to mysterious structures superimposed on the abdomen or pelvis. Such artifactual nonosseous findings can be minimized by close monitoring of the progress of the scan. Finally, even when appropriately performed, the SPECT imaging process may at times lead to patterns of projected activity that cross the soft tissues. Streaks of increased activity and photopenia extending outward from a full bladder on bone SPECT of the pelvis are a good example of this pitfall (16).

NONOSSEOUS FINDINGS RELATED TO URINARY SYSTEM

The most frequent nonskeletal incidental findings on bone scans are related to the genitourinary system (17).

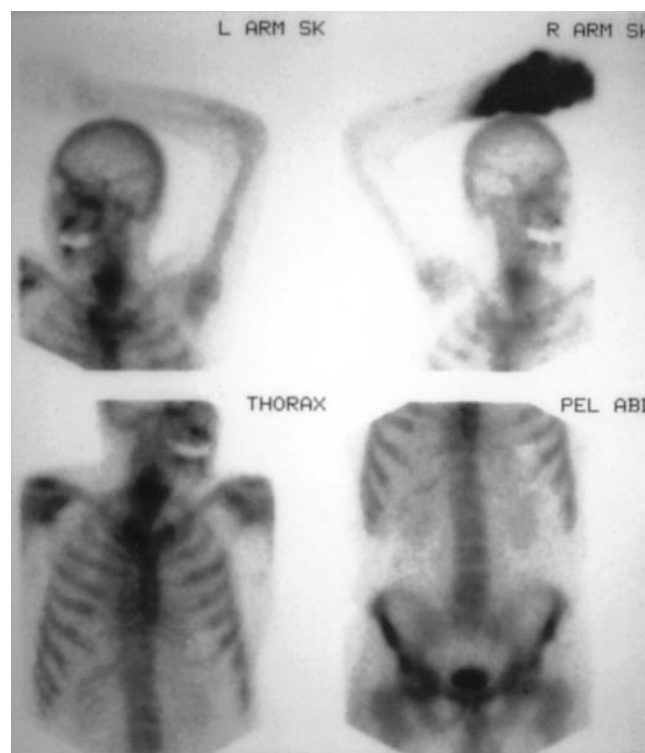


FIGURE 1. Injection of ^{99m}Tc -MDP into radial artery of right hand produces dramatic soft-tissue uptake in arterial distribution along lateral side of hand and wrist (anterior view). SK = skull; PEL ABD = pelvis and abdomen.

Abnormalities of renal size, position, and structural integrity are identifiable on whole-body bone scans, and comments on the status of the kidneys and bladder have become a constant feature in bone scan reports. Examples of such findings range from the clinically insignificant (such as a ptotic kidney) to the photopenic kidney defect that proves to be cancer (Fig. 2) (18). In addition, findings related to the urinary collecting tracts, such as a dilated pelvicaliceal system, can be observed (19). For example, a patient with newly diagnosed prostate cancer who is undergoing bone scanning to exclude metastases may have the unexpected finding of a dilated, obstructed ureter (Fig. 3)—which the urologist may or may not have identified on prior studies such as contrast-enhanced CT. Whether incidental urinary findings bear any significance to the patient's condition remains, however, controversial. In our own series (unpublished), the incidence of urinary tract findings was 15%. However, most of these findings were already known to be present before bone scanning. The evaluation of the genitourinary system on routine bone scans is crude and limited when compared with the renogram or CT scan. However, occasionally the patient's diagnostic problem will be solved by carefully inspecting the genitourinary findings on a bone scan. For example, the bone scan may reveal an unknown renal problem, such as hydronephrosis, that could explain a patient's low-back pain and lead the clinician to appropriate diagnostic testing and therapy (20).

SOFT-TISSUE FINDINGS ON BONE SCANS

A plethora of bone scan cases featuring soft-tissue or visceral uptake can be found in the medical literature. Such findings also occur frequently in one's own clinical practice. Excluding the technical artifacts and the genitourinary causes already mentioned, various pathophysiologic mechanisms have been postulated for soft-tissue uptake. For example, deposition of the bone radiotracer in heterotopic new bone formation (e.g., myositis ossificans) follows a pathway similar to bone localization (21). Although bone scanning is frequently ordered for evaluation and follow-up of known heterotopic ossification (22), the incidental find-

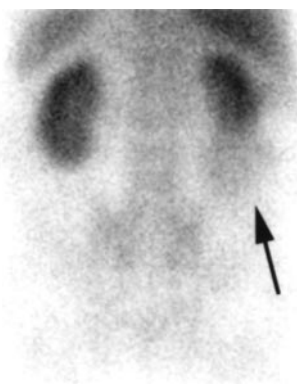


FIGURE 2. Blood-pool image of posterior lower back shows blunting of lower pole of right kidney and uptake in soft-tissue mass (arrow), which proved to be renal cell carcinoma.



FIGURE 3. Grossly dilated left ureter and renal collecting system seen on anterior whole-body ^{99m}Tc -MDP bone scan of patient with prostate cancer. Indwelling Foley catheter was in place at time of scanning.

ing of uptake around the joints and in certain muscles can be a prelude to clinical presentation of heterotopic ossification in these cases (23).

In other situations of soft-tissue visualization, the mechanism of uptake is less well defined although soft-tissue calcification is thought to play an important role (24). Because calcium deposition in the soft-tissue can be found in a variety of disease processes (such as ischemia, necrosis, metastatic calcification in renal failure, or hypercalcemia of any cause), it is conceivable to find uptake of the bone radiotracer in any organ in the body. However, this is an oversimplification; the uptake patterns occurring in individual organs usually point to a specific pathology. For example, cardiac uptake might be due to a recent myocardial infarction or to the presence of amyloid deposits (25).

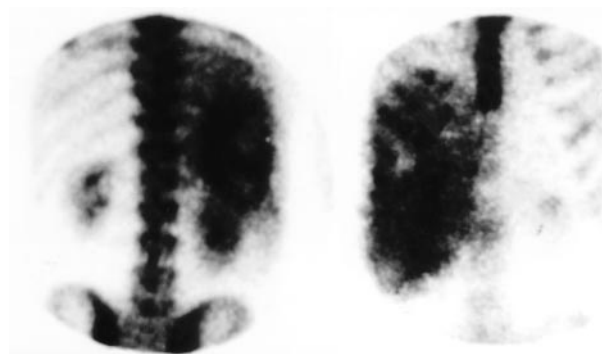


FIGURE 4. Anterior (right) and posterior (left) abdominal views of ^{99m}Tc -MDP bone scan of patient with hepatic metastasis from colon carcinoma show intense uptake of radioactivity in liver, which is heavily involved with tumor.

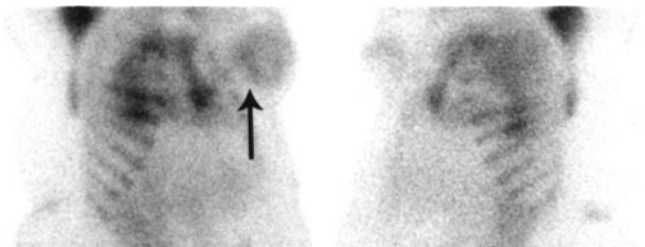


FIGURE 5. Left anterior oblique (right) and right anterior oblique (left) views of chest from ^{99m}Tc -MDP bone scan of patient with left-breast cancer show soft-tissue uptake in both breasts. Uptake in left breast is more extensive (arrow) and corresponds to tumor mass on that side.

Pleural effusions may be delineated on the bone scan by diffuse increased uptake in a hemithorax. Such pleural uptake indicates a malignant effusion and is an ominous sign in patients scanned for skeletal metastases (26). The spleen may be seen on the bone scan of sickle cell patients (27), whereas uptake in the liver may indicate metastases from colon cancer (Fig. 4) (28). The renal parenchyma may show uptake on the bone scan because of hypercalcemia (29), posttransfusion changes (30), or irradiation (31).

Finally, bone scanning has been advocated for evaluation of some soft-tissue tumors. For example, neuroblastoma and breast carcinoma are known to concentrate ^{99m}Tc -MDP (Fig. 5) (32). However, the clinical usefulness of ^{99m}Tc -MDP in this situation has not been established. A summary of clinically significant soft-tissue findings on bone scans is presented in Table 2. However, new artifacts and pitfalls in the form of unexpected soft-tissue uptake continue to occur in our clinical practice. Shown in Figure 6 is a recently encountered example of incidental soft-tissue uptake at a lower-back medication injection site that masqueraded as pathology on the bone scan.

CONCLUSION

Incidental nonosseous uptake on bone scans is occasionally seen. The uptake could be artifactual and due to a flaw in the procedure. Recognition of such occurrences helps to

TABLE 2
Soft-Tissue Uptake That Often Is Clinically Significant

Organ or tissue	Pathologic condition
Breast	Breast cancer
Pleural space	Malignant effusion
Liver	Calcified or necrotic metastases
Heart	Amyloidosis or infarction
Spleen	Sickle cell disease
Brain	Infarction
Muscle	Heterotopic ossification or myositis
Stomach	Hypercalcemia, metastatic calcification
Lung	Hypercalcemia, metastatic calcification
Renal cortex	Hypercalcemia
Joints	Osteochondromatosis
Pericardium	Pericarditis or malignant effusion
Soft-tissue tumor	Osteogenic sarcoma or malignancy

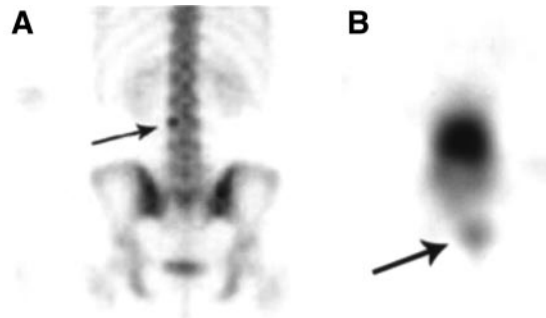


FIGURE 6. (A) Planar posterior image of lower back from ^{99m}Tc -MDP bone scan of patient with chronic back pain. Focus of increased uptake is seen in region of left pedicle of 3rd lumbar vertebra (arrow). (B) SPECT image shows this uptake to be more superficial in overlying soft tissue (arrow). Patient had received injections of antiinflammatory drugs at this site a few weeks before scan.

rectify the error and obtain the proper study. True nonosseous findings are related mainly to the urinary system. Most of the genitourinary abnormalities seen on the scan would be known from the clinical history or prior imaging investigations. Nevertheless, mention of such findings has become an integral part of the nuclear medicine report. Visualization of other organs can be expected and readily explained in certain conditions, such as splenic uptake in patients with sickle cell disease. However, in a few cases, incidental findings such as a previously unrecognized malignant pleural effusion in a patient with cancer can have an impact on patient management. The main purpose of the bone scan in most cases, however, remains to address abnormalities of the skeleton. This can be achieved only by using meticulous technique and appropriate assessment of the patient's condition. In this context, obtaining a relevant medical history including a review of medications and other imaging studies will put the clinical problem in perspective and clarify incidental soft-tissue findings on the bone scan.

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CONTINUING EDUCATION TEST: Nonosseous Abnormalities on Bone Scans

For each of the following questions, select the best answer. Then circle the number on the CE Tests Answer Sheet that corresponds to the answer you have selected. Complete the answer sheet. Keep a record of your responses so that you can compare them with the correct answers, which will be published in the next issue of *JNMT* after the test return deadline. Answers to these test questions should be returned on the Answer Sheet no later than **September 30, 2004**. An 80% correct response rate is required to receive 1.0 CEH (Continuing Education Hour) credit for each article. SNM Technologist Section members can find their VOICE number on the upper left-hand corner of their *JNMT* mailing labels. If you've joined our Nonmember VOICE Tracking Program, please write *NMVT* on the Answer Sheet (no extra fee is required). Documentation will appear on your VOICE transcript. Nonmembers who have not joined our Nonmember VOICE Tracking Program must mail a \$10.00 check or money order, made payable to SNM, for each completed quiz. You will receive a certificate of completion indicating credit awarded for receiving a passing score of 80% or better. All articles are approved by the Florida Department of Health Bureau of Radiation Control.

A. *In addition to allowing visualization of the skeleton, ^{99m}Tc -MDP bone scans show the following organ as a normal finding:*

101. Heart
102. Liver
103. Kidney
104. Bowel
105. Salivary gland

B. *Free ^{99m}Tc -pertechnetate in the ^{99m}Tc -MDP preparation can lead to visualization of the ____ on 3-h delayed images.*

106. Lung
107. Stomach
108. Gallbladder
109. Kidneys
110. Spleen

C. *Generalized failure of the bones to accumulate ^{99m}Tc -MDP is most likely caused by:*

111. Radiotherapy
112. Diphosphonate therapy
113. Hypercalcemia
114. Salicylates
115. Very young age

D. *Intraarterial injection of the bone radiopharmaceutical (^{99m}Tc -MDP) will:*

116. Go undetected
117. Cause gangrene
118. Interfere with the entire whole-body image
119. Produce uptake in the arterial distribution
120. Increase the local radiation dose

E. *Streaky photopenia on pelvic SPECT performed as part of a ^{99m}Tc -MDP bone scan is most likely due to:*

121. Patient motion
122. Camera nonuniformity
123. Attenuation in an obese patient
124. Inappropriate filtering
125. A full bladder

F. *A dilated ureter on the bone scan is most likely to be seen in a patient with:*

126. Cardiac failure
127. Myositis ossificans
128. Prostate cancer
129. Low-back pain
130. Multiple trauma

G. *Cardiac uptake of ^{99m}Tc -MDP may be due to:*

131. Palpitations
132. Mitral regurgitation
133. Myocardial infarction
134. Aortic stenosis
135. Bacterial endocarditis

H. *A nonosseous finding on a ^{99m}Tc -MDP bone scan that should raise a high level of suspicion for malignancy is:*

136. Uptake in a hemithorax
137. Gastric uptake
138. Splenic uptake
139. Renal uptake
140. Periarticular uptake

I. *Nonosseous abnormalities on a ^{99m}Tc -MDP bone scan are most frequently seen in:*

- 141. The connective tissue and muscle
- 142. The genitourinary system
- 143. The gastrointestinal system
- 144. Any tissue in which cancer is present
- 145. No specific organ or system

J. *In a patient with a history of colon carcinoma, liver uptake on a ^{99m}Tc -MDP bone scan is likely to represent:*

- 146. Liver failure
- 147. Liver obstruction
- 148. Liver cirrhosis
- 149. Hepatomegaly
- 150. Metastasis to the liver

K. *Nonosseous findings due to technical artifacts can be minimized by:*

- 151. Marking or recording the site of injection
- 152. Obtaining a list of patient medications
- 153. Monitoring the progress of the scan
- 154. Taking the patient's medical history
- 155. All of the above

L. *The main purpose of ^{99m}Tc -MDP bone scintigraphy is to detect:*

- 156. Bone abnormalities
- 157. Bone and soft-tissue abnormalities
- 158. Bone malignancy
- 159. Soft-tissue malignancy
- 160. Any organ abnormality including bone

Answers to CE Article Test, June 2002

The CE article "Data Acquisition in PET Imaging" by Fahey was accompanied by a CE test. The correct answers are:

- | | | | | |
|--------|--------|--------|--------|--------|
| A. 102 | D. 114 | G. 127 | J. 139 | M. 148 |
| B. 107 | E. 120 | H. 132 | K. 141 | N. 154 |
| C. 109 | F. 121 | I. 133 | L. 146 | O. 159 |

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**CONTINUING EDUCATION TEST
Nonosseous Abnormalities on Bone Scans**

Answer Sheet

101	105	109	113	117	121	125	129	133	137	141	145	149	153	157
102	106	110	114	118	122	126	130	134	138	142	146	150	154	158
103	107	111	115	119	123	127	131	135	139	143	147	151	155	159
104	108	112	116	120	124	128	132	136	140	144	148	152	156	160

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