Continuing Medical Education Article

Dynamic Bone Imaging with $^{99m}$Tc-Labeled Diphosphonates and $^{18}$F-NaF: Mechanisms and Applications

*JNM*, April 2013, Volume 54, Number 4

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Disclosure

In accordance with ACCME Revised Standards for Commercial Support and SNM Conflict-of-Interest Policy, the authors have indicated no relevant relationships that could be perceived as a real or apparent conflict of interest. Disclosure of a relationship is not intended to suggest or to condone bias but is made to provide participants with information that might be of potential importance to their evaluation of the activity.

Target Audience

This article contains information of value to nuclear medicine physicians, radiologists, nuclear medicine technologists, and clinicians utilizing skeletal imaging.

Objectives

On successful completion of this activity, participants should be able to…

1. Appreciate the physiologic mechanisms underlying uptake of bone-seeking radiopharmaceuticals used to assess bone perfusion and turnover and note the differences between $^{18}$F-NaF and $^{99m}$Tc-labeled diphosphonates.

2. Discuss the use of bone scintigraphy for evaluation of bone viability and metabolic bone disorders and appreciate the potential role of quantitative dynamic $^{18}$F-NaF PET for evaluation of response to therapy.

3. Discuss indications for $^{99m}$Tc-labeled diphosphonate bone scans and $^{18}$F-NaF PET/CT for oncologic staging and appreciate quantitative methods on static and dynamic bone imaging as imaging biomarkers of treatment response using novel systemic therapies for metastatic castrate-resistant prostate cancer as a model.
1. Autoradiography has shown that bone-seeking radiotracers such as $^{99m}$Tc-diphosphonates localize in which part of bone?
A. Medullary bone.
B. Bone marrow.
C. Mineralization front (osteoid).
D. Osteoclasts.

2. Using compartmental modeling for quantitative $^{18}$F-fluoride ion ($^{18}$F-NaF) PET, which kinetic parameter is most closely associated with bone metabolism (or bone turnover)?
A. $K_1$ (forward capillary transport).
B. $k_2$ (reverse capillary transport).
C. $k_3$ (binding to the bone matrix).
D. $K_i$ (net transport into bone).

3. Comparing $^{18}$F-NaF PET and $^{99m}$Tc-MDP bone scanning, which of the following statements is true?
A. Using typical administered doses in adults, the radiation effective dose for $^{18}$F-NaF PET is lower than that of $^{99m}$Tc-MDP bone scanning.
B. $^{18}$F-NaF PET can evaluate the soft-tissue phase (second phase) better than $^{99m}$Tc-MDP bone scanning.
C. $^{18}$F-NaF PET is less sensitive than $^{99m}$Tc-MDP bone scanning for detecting bone metastases from lung cancer.
D. $^{18}$F-NaF PET allows quantitative kinetic modeling not available with $^{99m}$Tc-MDP bone scanning.

4. Comparing dosimetry between $^{18}$F-NaF PET and $^{99m}$Tc-MDP bone scanning, which of the following statements is correct?
A. $^{18}$F-NaF has a much lower effective dose than $^{99m}$Tc-MDP due to the short 109-min physical half-life of $^{18}$F.
B. With $^{99m}$Tc-MDP, the bladder wall is the organ receiving the largest radiation dose.
C. With $^{18}$F-NaF, the bone surfaces are receiving the largest radiation dose.
D. Patient preparation for $^{18}$F-NaF PET should include good hydration to reduce the effective radiation dose to the patient.
5. Which pattern on 3-phase $^{99m}$Tc-MDP bone scanning is most predictive of viability and a subsequent uncomplicated healing course for a vascularized fibula graft in the mandible?
   A. Increased uptake in the graft at 2–11 d after surgery.
   B. Decreased uptake in the graft at 2–11 d after surgery.
   C. Increased uptake in the graft at 3 mo after surgery.
   D. Decreased uptake in the graft at 3 mo after surgery.

6. Which of the following is a new efficacious radionuclide therapy for castrate-resistant prostate cancer?
   A. Cabazitaxel.
   B. Sipuleucel-T.
   C. Denosumab.
   D. $^{223}$Ra-dichloride.

7. Bone metastases from which cancer type are more readily detected with bone scanning (either $^{18}$F-NaF PET or $^{99m}$Tc-MDP) than with $^{18}$F-FDG PET?
   A. Prostate cancer.
   B. Lung cancer.
   C. Colorectal cancer.
   D. Breast cancer.

8. Which quantitative parameter on either $^{18}$F-NaF PET or $^{99m}$Tc-MDP bone scans is indicative of a successful response to risedronate in Paget disease?
   A. Increasing whole-body retention index on $^{99m}$Tc-MDP bone scanning.
   B. Decreasing plasma clearance of $^{18}$F-NaF radiotracer to the skeleton on PET imaging.
   C. Increasing regional SUV in affected bone on $^{18}$F-NaF PET.
   D. Decreasing renal clearance of $^{99m}$Tc-MDP radiotracer on bone scintigraphy.

9. Monitoring of treatment effects on bone mineral density in osteoporosis is best performed using which test?
   A. Quantitative $^{18}$F-NaF PET.
   B. Serum alkaline phosphatase measurements.
   C. Whole-body retention index on $^{99m}$Tc-MDP bone scanning.
   D. Dual-energy x-ray absorptiometry.
10. Bisphosphonate pharmaceuticals have a high affinity to which part of bone?
A. Bone marrow.
B. Osteoclasts.
C. Medullary bone.
D. Inorganic bone matrix.