Bone Scintigraphy Guideline

1. Purpose

This guideline must be read in conjunction with the BNMS Generic guidelines.

The purpose of this guideline is to assist specialists in Nuclear Medicine and Radionuclide Radiology in recommending, performing, interpreting and reporting the results of bone scintigraphy studies. This guideline could also be used to help individual departments formulate their own local protocols. This does not aim to be prescriptive regarding technical aspects of individual camera acquisitions which should be developed in conjunction with the local medical physics expert.

2. Background.

Radionuclide bone scintigraphy or 'bone scanning' is a highly sensitive means of identifying regions of increased bone and joint metabolism. The radiopharmaceuticals used for bone imaging are ^{99m}Tc labelled phosphates. The mechanism of uptake of the radiopharmceutical by a particular bony region is determined by the local level of blood flow to allow delivery of the tracer to the region and the degree of osteoblastic activity, which determines the concentration of the tracer. Sensitivity of bone scintigraphy for the demonstration of bone and joint pathology is high if the pathology involves increased osteoblastic activity and bone scans are often able to detect bone and joint pathology earlier than other modalities. However, given that osteoblastic activity occurs in response to a very wide range of pathologies, the specificity of bone scintigraphy can be poor. The cause of osteoblastic activity often requires further clarification with consideration of the history, pattern of tracer uptake and correlation with imaging from other modalities, such as by hybrid SPECT-CT to establish the aetiology of abnormal tracer concentration.

3. Conditions which are commonly investigated using bone scintigraphy include:

a. Benign neoplastic	osteoid osteoma
b. Malignant neoplastic	primary: osteosarcoma, secondary: metastases
c. Inflammatory	inflammatory arthropathies
d. Infective	osteomyelitis, discitis, septic arthritis
e. Neurovascular	avascular necrosis, reflex sympathetic dystrophy
f. Metabolic	osteomalacia, Paget's disease
g. Trauma	fracture, insufficiency fracture, Charcot's joint, shin splints, NAI*
h. Post surgical	post operative periprosthetic or fixation device complication
i. Degenerative	osteoarthritis
j. Non-bony	rhabdomyolysis, myositis ossificans.

* some maintain that bone scintigraphy is unhelpful in the context of non accidental injury (NAI) as it can be difficult to date an injury with confidence for legal purposes.

4. Contraindications.

a. Absolute: Pregnancy
b. Relative: Breastfeeding
c. Relative: Pathology which has a predominantly osteoclastic process resulting in lytic lesions such as multiple myeloma which are unlikely to concentrate the tracer
d. Relative: Trauma or surgery to the region of interest within the previous 6-12 month
due to inability of osteoblastic activity relating to normal post-traumatic or post-operative resolution to be distinguished from that due to post operative complications.

5. Radiopharmaceuticals and dose

^{99m}Tc labelled hydroxymethylene diphosphonate (HMDP), ^{99m}Tc disodium oxidronate (HDP) or ^{99m}Tc methylene diphosphonate (MDP)

ARSAC DRL for adults: 600 MBq for planar imaging and 800MBq for SPECT.

6. Radiation exposure The effective dose from bone scintigraphy is 3mSv for planar imaging (600MBq) and 5mSv for SPECT (800MBq)

7. Patient preparation Patients should be very well hydrated to ensure background tissue clearance is optimised and to help minimize radiation exposure to the bladder and adjacent organs.

8. Imaging Procedure The study should be tailored to the individual patient and the differential diagnosis. Standardised protocols are required to ensure the highest quality images are acquired. The technical details of image acquisition need to be established by departments on individual cameras following collaboration with the local medical physics expert; the parameters given here are for demonstrative purposes only.

a. Angiographic and early blood pool phase imaging

If demonstration of vascular supply is required to aid clinical interpretation, a multiphase study should be performed with dynamic image acquisition during tracer injection. Image acquisition can be performed during the angiographic or perfusion phase and/or early blood pool phase to give (with the delayed bone phase study) a dual or triple phase study.

Conditions which may benefit from consideration of a dynamic dual or triple phase study include:

a. Inflammatory/infective conditions such as osteomyelitis or septic arthritis
b. Conditions which affect the blood supply to an area such as avascular necrosis, reflex sympathetic dystrophy.
c. Primary neoplastic conditions with increased vascularity: osteoid osteoma.

Examples of technical aspects of dynamic/early blood pool phase bone scans are shown in the following tables: a.1 Angiographic or perfusion phase acquisition, a.2 Early blood pool phase acquisition

Table a.1 An example of technical aspects of an angiographic or perfusion phase acquisition:	
Patient Position:	As required with the camera as close as possible to the area being imaged
Views Required:	Anterior view of the area of interest
Time Delay:	0 mins
Approx Imaging Time:	5 minutes
Zoom:	As appropriate
Isotope:	Tc-99m (140keV ± 10%)
Collimator:	LEGP
Matrix:	64 x 64
Stop condition:	180 frames at 1 sec per frame

Table a.2: An example of technical aspects of an early blood pool phase acquisition.	
Patient Position:	As required with the camera as close as possible to the area being imaged
Views Required:	Anterior view of the area of interest
Time Delay:	3-5 minutes (within 15 minutes)
Approx Imaging Time:	1 minute
Zoom:	As appropriate
Isotope:	Tc-99m (140keV ± 10%)
Collimator:	LEGP
Matrix:	64 x 64 does this give enough resolution?
Stop condition:	1 frame at 60 sec per frame

b. Delayed bone phase imaging

Bone phase imaging is performed at 2-3 hours following injection of tracer. This delay allows optimal concentration of tracer by active osteoblasts and allows time for background tissue tracer to be cleared and renally excreted. Image acquisitions are tailored to the patient and the differential diagnosis. The bladder should be emptied prior to imaging if this includes the pelvis. Any clothing, pocket contents or jewellery which may cause attenuation should be removed. The patient should be supported to ensure comfort and reduce movement during the scan acquisition.

'Static' or 'spot' images can be performed with a high resolution collimator and stationary camera and couch to maximize linear resolution of a small region of interest. This is

generally used for small joints and paediatric cases. Example of scanning parameters are shown in table b.1.

Whole body bone scans are acquired using a sliding acquisition which images the whole skeleton in continuity. Anterior and posterior views are acquired simultaneously when using a dual headed camera. This is commonly used in oncology staging studies. Examples of scanning parameters are shown in table b.2.

Single photon emission computed tomography (SPECT) can be used to produce cross sectional images in orthogonal planes and may also be used to separate and define the anatomy. SPECT is often used in scanning regions with complex overlying anatomy which may be difficult to interpret from planar images such as the skull, spine, hands and feet. Examples of scanning parameters are shown in table b.3.

All delayed bone phase images need to be assessed immediately and repeated if images are suboptimal due to movement, suboptimal positioning, attenuation from jewellery or urinary contamination artefacts.

Table b.1: An example of technical aspects of a static or spot view acquisition.	
Patient Position:	As required with the camera as close as possible to the area being imaged.
Views Required:	Anterior and posterior view of area of interest or obliques as required
Time Delay:	3 hours
Approx Imaging Time:	15mins
Zoom:	As appropriate
Isotope:	Tc-99m (140keV ± 10%)
Collimator:	LEHR
Matrix:	256 x 256
Stop Condition:	500,000 counts or 7 minutes

Table b.2: An example of technical aspects of a whole body bone scan acquisition.	
Patient Position:	Feet first supine, arms by side with pillow supporting knees and head, camera heads as close as possible
Views Required:	Whole Body Anterior and Posterior
Time Delay:	3 hours (not less than 2.5 hours)
Approx Imaging Time:	30mins
Zoom:	None
Isotope:	Tc-99m (140keV ± 10%)
Collimator:	LEHR/CHR
Matrix:	256x1024
Stop Condition:	Scan speed 10cm/minute. Stop at feet.

Table b.3: An example of technical aspects of a SPECT acquisition:	
Patient Position:	Feet first supine, arms by side with small pads supporting knees and head, camera heads as close as possible
Views Required:	SPECT area of interest
Time Delay:	3 hours
Approx Imaging Time:	25mins
Zoom:	None
Isotope:	Tc-99m (140keV ± 10%)
Collimator:	LEHR
Matrix:	128 x 128
Stop Condition:	360 degree arc, 120 views at 20s per view.

8. Patient After Care

To minimise the radiation dose to the patient, they should be encouraged to maintain a high fluid intake following the scan and to empty their bladder regularly.

10. Image interpretation

Nuclear medicine images should be reported by the relevant ARSAC certificate holder or those delegated by them to perform this role.

Accurate image interpretation depends on sound knowledge and extensive experience of the normal range of tracer distribution to help distinguish significant pathology from normal or trivial pathology. Studies which can be particularly difficult to interpret with confidence without adequate experience are those which are symmetrical such as superscans (metabolic or metastatic) where an elevated axial to peripheral ratio of count density may be difficult to perceive, and paediatric bone scans due to potential difficulties in epiphyseal plate activity interpretation.

As bone tracer concentration reflects osteoblastic activity which is a common response to a wide range of pathologies, a focus of abnormal tracer concentration should not be confidently assigned to a particular pathology without a typical pattern of tracer distribution such as multiple randomly placed foci in metastatic bone disease or multiple aligned foci of rib uptake in trauma. In the absence of this, correlation of foci or uptake with alternative modality images such as plain radiographs, MR or CT images should be reviewed when available as this can significantly increase the accuracy of bone scintigraphy interpretation. SPECT-CT fused hybrid imaging has been demonstrated to significantly improve the accuracy of bone scintigraphy interpretation when the CT component may be justified for indeterminate lesions and complex joint interpretation such as the spine and feet. The CT component may also be used in attenuation correction of SPECT images. There is evidence of substantially increased interobserver agreement in bone scan interpretation with hybrid SPECT-CT as demonstrated by weighted kappa scores of 0.56 for SPECT alone and 0.87 for SPECT-CT (1) and improved ROC curves in bone scan interpretation of 0.771 (SPECT alone), 0.885 (SPECT correlated with separate CT) and 0.968 (fused hybrid SPECT-CT) (2).

11. Reporting

Structured reports are recommended to include indication, technique, study description including both positive and negative findings, correlation with previous bone scans or alternative modalities if appropriate, conclusion and recommendations for further evaluation.

12. Auditable aspects

Bone scan studies are a good subject for departmental audits, which may include assessments of image quality (tissued doses, urinary contamination, patient positioning, use of supplementary views etc) and reporting quality.

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1. Eur J Nucl Med Mol Imaging. 2010 Apr;37(4):706-13
2. Radiology. 2006 Jan; 238(1): 264-71.