

# Role of 99mTc-Methylene Diphosphonate Bone Scintigraphy in the Evaluation of the Viability and the Incorporation of the Bone Allograft Used in Orthopedic Reconstruction

## Abstract

Allogenic bone is the most commonly grafted tissue which provides only osteoconductive property, in which it acts as a scaffold to facilitate the ingrowth of the vessels and migration of host cells capable of osteogenesis. It can be used as a substitute for autografts as the latter is associated with morbidity and limited donor site availability. Its applications are expanding in all aspects of orthopedic surgery, notably in revision hip replacement or surgical treatment for bone tumors or benign conditions. The balance between osteolysis and osteogenesis must be maintained for graft incorporation to occur and thus postoperative imaging is essential for differentiation between grafts and recurrent disease or viability/nonviability. Here, we present three cases, in which bone allografting was done who underwent serial 99 mTc-methylene diphosphonate three-phase bone scintigraphy with single-photon emission computed tomography/computed tomography to assess the viability, integrity, and the incorporation of the graft.

**Keywords:** 99 mTcmethylene diphosphonate bone scintigraphy, bone allograft, orthopaedic reconstructive procedure, osteoblastic activity, single-photon emission computed tomography, viability

**Anjali Meena,  
Hardik Veerwal,  
Vandana Kumar  
Dhingra,  
Mohit Dhingra<sup>1</sup>**

*Departments of Nuclear  
Medicine and <sup>1</sup>Orthopedics,  
All India Institute of  
Medical Sciences, Rishikesh,  
Uttarakhand, India*

## Introduction

Bone allografting is an orthopedic procedure that is used in myriad of clinical settings which includes filling up cavitory lesion, reconstruction of osteoperiosteal defects, or reconstruction following joint replacements. The main complications after allografting are infection, fracture, nonunion, and failure of incorporation.

Bone scintigraphy can be used to reflect the physiological and metabolic activity of the bone, thus helping in assessing the viability and integrity of the graft. This depends on the intrinsic bone-forming properties and mechanical stability of the graft and host-graft contact surface area. The graft may be partially or completely reabsorbed as the new bone is formed on the surface of the graft through “creeping substitution”.

## Case Reports

### Case 1

A 23-year-old male, case of chondromyxoid fibroma of left distal humerus postextended

curettage and allogenic bone grafting with medial plating, was referred for 99 mTc-MDP bone scan to assess the viability and incorporation of the graft in view of mild pain and swelling 1 month postsurgery. Serial scintigraphy revealed increased osteoblastic activity, which was more at 3<sup>rd</sup> month and decreased at 12<sup>th</sup> month [Figure 1a-f]]. The persistent diffuse uptake is likely due to the continuous mechanical stress. Absent of increased blood flow and hyperemia [Figure 2a-f] correlated well with healing and no future complications of the graft. Reduction and homogenization of osteoblastic activity [Figure 1a-f] are likely suggestive of incorporation of the graft.

### Case 2

A 40-year-old female, case of aneurysmal bone cyst of the right proximal femur with pathological fracture status postclosed reduction-internal fixation and dynamic hip screw with allogenic bone graft. She underwent 99 mTc-MDP three-phase scintigraphy after 1 month of surgery in view of swelling and restriction while

### Address for correspondence:

*Dr. Vandana Kumar Dhingra,  
Department of Nuclear  
Medicine, All India Institute of  
Medical Sciences, Virbhadra  
Road, Rishikesh - 249 203,  
Uttarakhand, India.  
E-mail: modisbanu@yahoo.com*

Received: 06-07-2021

Accepted: 31-08-2021

Published: 25-03-2022

### Access this article online

Website: [www.ijnm.in](http://www.ijnm.in)

DOI: 10.4103/ijnm.ijnm\_104\_21

### Quick Response Code:



**How to cite this article:** Meena A, Veerwal H, DhingraVK, Dhingra M. Role of 99mTc-methylene diphosphonate bone scintigraphy in the evaluation of the viability and the incorporation of the bone allograft used in orthopedic reconstruction. Indian J Nucl Med 2022;37:74-7.

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: [WKHLRPMedknow\\_reprints@wolterskluwer.com](mailto:WKHLRPMedknow_reprints@wolterskluwer.com)

walking followed by serial scans at 10<sup>th</sup> and 16<sup>th</sup> month postsurgery.

The absence of increased blood flow and no significant hyperemia was noted at 1 month which helped ruling out the infection around the screw [Figure 3a-f]. Increased osteoblastic response at 1 month was thought to be associated with postoperative changes, followed by reduction of activity which was more homogenous to normal cortical bone by 10<sup>th</sup> month, suggesting ongoing osteoblastic healing [Figure 4a-f].

### Case 3

A 19year old male, case of chondroblastoma right distal femur, presented with pain and restriction in knee

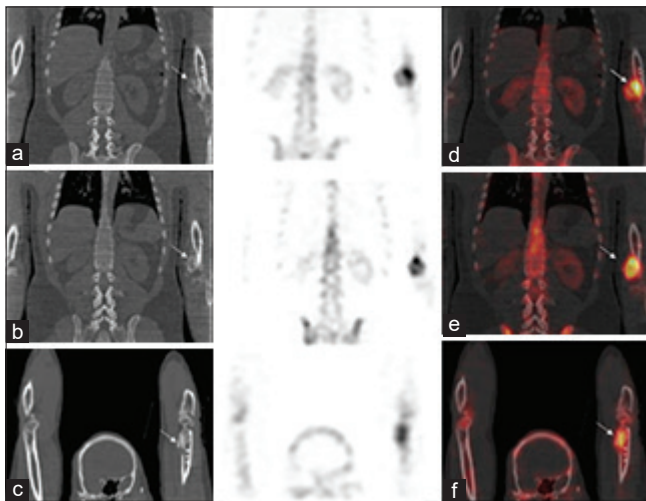


Figure 1: Single-photon emission computed tomography/computed tomography of the left distal humerus (d-f) shows better delineation of the increased osteoblastic activity which has reduced at 12th month with computed tomography images (a-c) showing maintained cortical outline and appearance of the graft becoming homogenous to surrounding cortical bone

movements 2years postintralesional curettage and allogenic bone grafting. 99mTc MDP bone scan revealed a focal area of inhomogenous increased activity [Figure 5a-b] even after 2years with lytic /sclerotic changes in the grafted area and irregular outline which is mostly suggestive of recurrent disease requiring further surgical exploration [Figure 6 a-d].

### Discussion

Extensive research is being undertaken regarding the usefulness of bone scintigraphy for evaluating the bone graft viability.<sup>[1,2]</sup> Combining anatomical and functional data helps in assessing the physiological activity of bone and increases the diagnostic yield of the scan. Evidence of bone viability and patency of microvascular anastomosis is reflected by the tracer uptake.

Complications are more frequent in negative scans after postoperative 1 week and not increase in the uptake in the following 1–3 months. Blood flow from three-phase bone scan reflects the integrity of the graft. Sequential bone scans are thus required to monitor the viability based on the uptake in the graft region.<sup>[3]</sup> Initial postoperative radiographs and computed tomography (CT) scans show high opacity of allografts, which gradually decreases over time, as graft incorporation progresses. When the union progresses due to trabecular ingrowth and fibrous tissue replaces the medullary canal, the junction between the graft host is obliterated as shown in our second case.<sup>[4]</sup>

It has an advantage being less prone to be affected by metal artifact compared to magnetic resonance imaging which also has a high burden of the cost and also shows the bones' metabolic activity that surrounds the prosthesis. Large grafts incorporate poorly with more frequent complications, whereas morselized allograft offers better results. New bone is formed on the surface of the graft by the phenomenon, known as “creeping substitution.”<sup>[5]</sup>

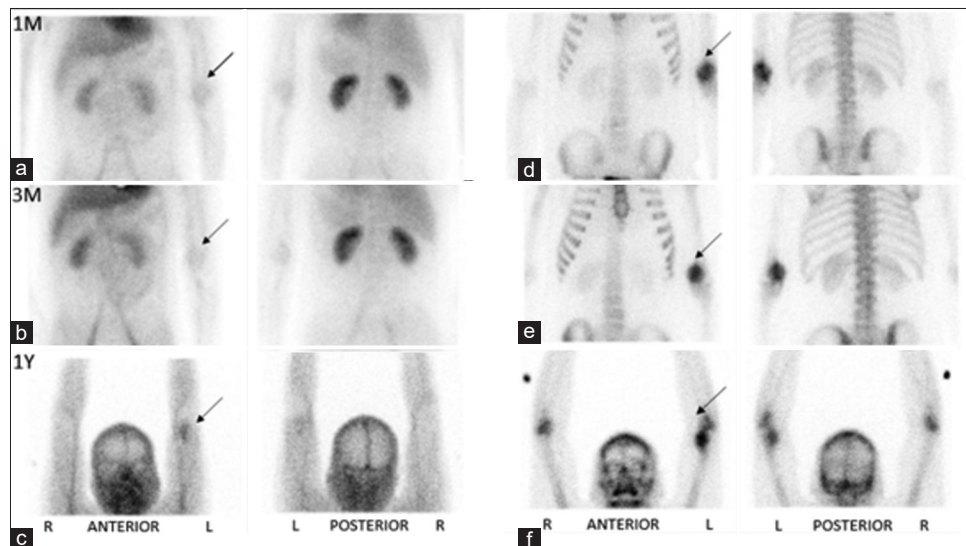
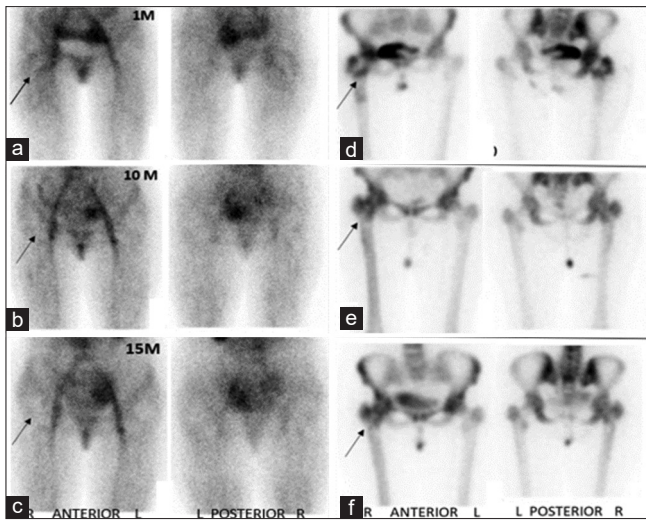
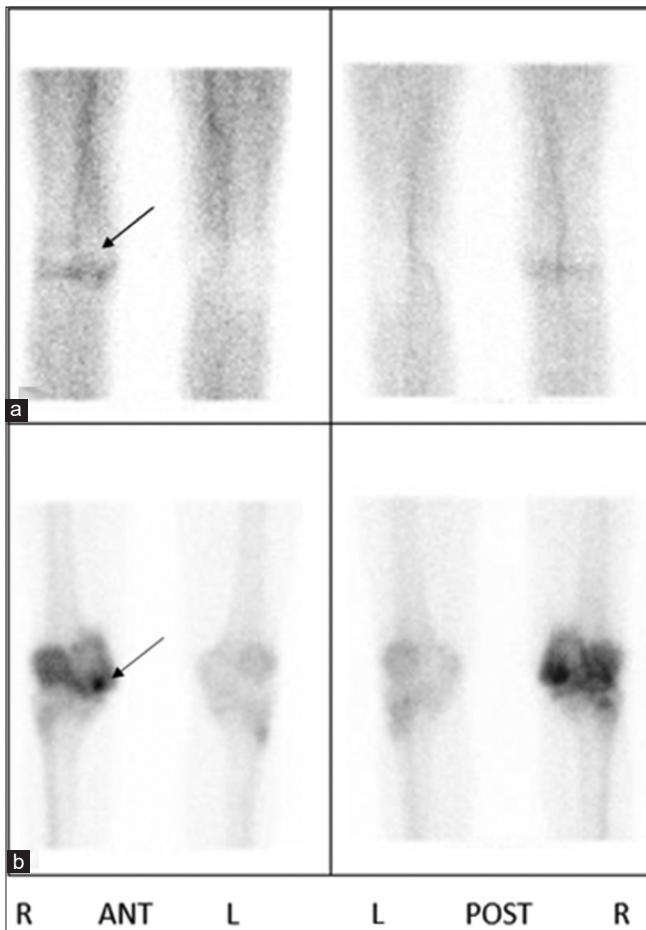


Figure 2: 99mTc-MDP serial blood pool (a-c) images reveal a focal area of mild hyperemia followed by normalization. Delayed 3 h spot images (d-f) reveals initially an increased followed by moderately reduced but well-circumscribed osteoblastic activity

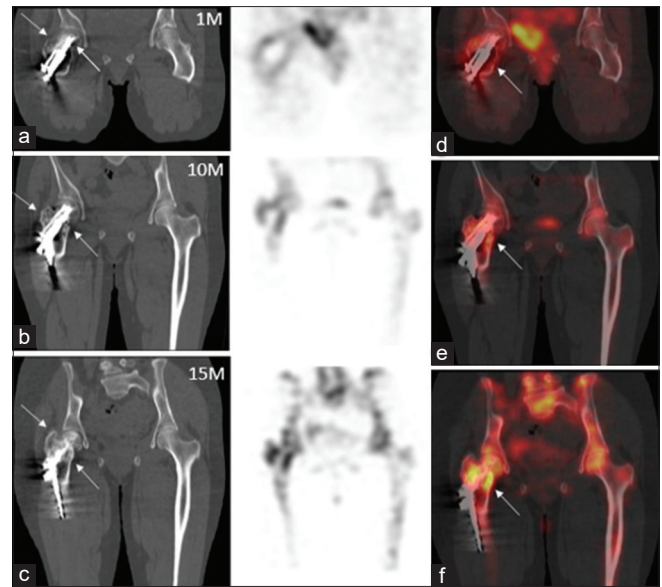


**Figure 3:** Blood flow images reveal normal tracer flow (not shown). Blood pool (a-c) reveals mild hyperemia initially with complete normalization by 15<sup>th</sup> month. Delayed spots (d-f) shows increased osteoblastic activity at the grafted region surrounding the screw which reduces in later months

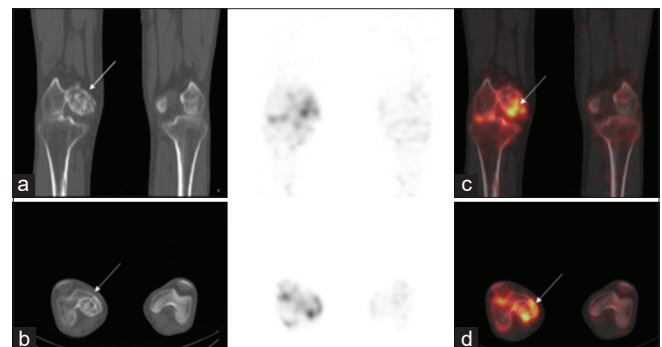


**Figure 5:** Blood flow was normal. Blood pool (a) of knee region reveals mildly increased tracer pooling in the right medial condylar region with a focal area of osteoblastic activity in delayed spots (b)

X-ray is beneficial only when there is 30%–40% alteration in the mineral content of the bone thus unreliable during the 1<sup>st</sup> month and also provides no



**Figure 4:** Single-photon emission computed tomography /computed tomography (d-f) of proximal femur localizes the increased osteoblastic activity in greater and lesser trochanter surrounding the screw with computed tomography images (a-c) revealing regular cortical outline with osteoblastic activity nearing the normal cortical bone in the later scans (b and c)



**Figure 6:** Single-photon emission computed tomography/computed tomography (c and d) of knee reveals a focal area of heterogeneously increased tracer activity in the medial condyle of the right femur with increased sclerotic and lytic changes on computed tomography (a and b) with irregular cortical outline, mostly suggestive of recurrence of the tumor

functional information regarding graft viability and integrity.<sup>[6]</sup> Bone resorption initially occurs at the margins of the allograft and is most prominent between 7 and 10 weeks postoperatively.

Radiodensity increases due to osteopenia of the surrounding bone and necrosis of the allograft and then starts to decrease approximately 6 months after transplantation and will continue this pattern for 18 months.<sup>[6-8]</sup> CT done simultaneously helps in revealing regular cortical outline and appearance which can be compared to normal surrounding bone or contralateral side.<sup>[3,9]</sup>

## Conclusion

We concluded that bone scan using 99 mTc-MDP with single-photon emission computed tomography/CT is an



overall one-stop shop simple, noninvasive investigation to assess the bone graft viability and its incorporation and provides a functional display of new bone formation, vascularity, and skeletal activity of the bone.

#### **Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

#### **Financial support and sponsorship**

Nil.

#### **Conflicts of interest**

There are no conflicts of interest.

#### **References**

1. Aydogan F, Akbay E, Cevik C, Kalender E. Blood-pool SPECT in addition to bone SPECT in the viability assessment in mandibular reconstruction. *Eur Rev Med Pharmacol Sci* 2014;18:587-92.
2. Moskowitz GW, Lukash F. Evaluation of bone graft viability. *Semin Nucl Med* 1988;18:246-54.
3. Droll KP, Prasad V, Ciorau A, Gray BG, McKee MD. The use of postoperative bone scintigraphy to predict graft retention. *Can J Surg* 2007;50:261-5.
4. Mushtaq N, To K, Gooding C, Khan W. Radiological imaging evaluation of the failing total hip replacement. *Front Surg* 2019;6:35.
5. Srivastava MK, Penumadu P, Kumar D, Pandit N. Role of (99m) Tc-methylene diphosphonate bone scan in the evaluation of the viability of the bone flap in mandibular reconstruction in patients with oromaxillofacial malignancies. *Indian J Nucl Med* 2015;30:280-2.
6. Beaman FD, Bancroft LW, Peterson JJ, Kransdorf MJ, Menke DM, DeOrio JK. Imaging characteristics of bone graft materials. *Radiographics* 2006;26:373-88.
7. García-Gómez FJ, López-Rodríguez E, García Perla García A, García-Jiménez R. New 3-dimensional single photon emission computed tomographic images in the assessment of the viability of microvascularised bone grafts after mandibular reconstruction. *Br J Oral Maxillofac Surg* 2016;54:704-6.
8. Buyukdereli G, Guney IB, Ozerdem G, Kesiktas E. Evaluation of vascularized graft reconstruction of the mandible with Tc-99m MDP bone scintigraphy. *Ann Nucl Med* 2006;20:89-93.
9. Schuind FA, Schoutens A, Noorbergen M, Burny F. Is early bone scintigraphy a reliable method to assess the viability of vascularized bone transplants? *J Reconstr Microsurg* 1993;9:399-403.