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Original Research Article

Role of Tc-99m MDP bone scan in evaluation of osteoid osteoma at varied locations

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ABSTRACT

Background: Osteoid osteoma is a benign bone tumor; diagnosed using x-ray and Computer Tomography (CT). It shows a nidus and cortical thickening. When the nidus is not well visualised especially in uncommon locations; Bone Scan (BS) can be performed for evaluation of osteoid osteoma.
Methods: A retrospective observational study was done where 21 subjects presenting with suspicion of osteoid osteoma underwent BS using 10-20mCi (370 to 740MBq) of Technetium-99m Pertechnetate with perfusion, delayed cortical and Single Photon Emission Tomography/Computer Tomography (SPECT/CT). Increased perfusion and delayed focal cortical uptake was assessed on BS to locate osteoid osteoma. Response evaluation to Radiofrequency ablation (RFA) was also performed using BS.
Results: Osteoid osteoma was detected in femur (8), spine (3), forearm bones (2), humerus (2), tibia (2), fibula in one and iliac bone in one patient using BS. BS detected more lesions (18) than CT scan where nidus as confirmatory sign was seen in 13 lesions. The McNemar test showed no significant difference (p=0.22) in the detection of osteoid osteoma using CT and BS in common location of femur. However there was significant difference noted between BS and CT in uncommon site (p=0.023). 3/8 patients showed persistent increased cortical activity after RFA ablation on BS.
Conclusions: BS was more useful for confirmation of diagnosis of Osteoid osteoma for lesions in uncommon sites. BS also helped to assess response to RFA ablation therapy. SPECT/CT improved interpretation of BS to locate the osteoid osteoma.

Keywords: Bone scan, Nidus, Osteoid osteoma, SPECT/CT

INTRODUCTION

Osteoid osteoma is a type of benign bone-forming tumor, which is characterized as a well-demarcated osteoblastic mass, called a nidus, surrounded by a distinct zone of reactive bone sclerosis; these tumors have limited growth potential and exhibit disproportionate pain.[1] In the majority of osteoid osteoma cases, typical radiographic features demonstrate a sclerotic cortical lesion and contain a small lucency that represents a nidus.[2,3] However, contrary to the expected presentation of osteoid osteoma, different radiographic findings may be encountered that provide a diagnostic dilemma for the physicians concerned.[4]

The peripheral sclerotic reaction zone is composed of osteoblasts, osteoclasts and dilated capillaries surrounding the nidus.[5,6] Peripheral nerve are abundant in and around an osteoid osteoma which is a unique feature in this tumor.[6] Prostaglandins are found in the nidus at

levels 100 to 1000 times that of normal tissue.[7] They induce vasodilatation and a resultant increased capillary permeability in the tissues surrounding the lesion and are believed to mediate tumor related pain, classically described as night pains relieved by salicylates. However, the inter-articular lesions have shown less response to non- steroidal anti-inflammatory drugs (NSAIDS) compared to the extra-reticular lesions.[8,9] Depending on the site of origin, there are three types of radiographic features; cortical, medullary and subperiosteal. Cortical osteoid osteoma is the classic type of the disease consisting of a small central nidus, usually radiolucent, associated with perifocal dense bone. These lesions may appear as high density and may require over-penetrated exposures or body section techniques to visualize the nidus. The density (sclerosis) is mostly adjacent to the nidus.[5,10,11]

In cases of osteoid osteoma in small bones and the spine, the nidus may not be visible on plain radiographs; therefore, additional imaging studies, including Computer Tomography (CT) and Magnetic Resonance Imaging (MRI) and additional imaging may be required for the confirmation of diagnosis.[4,11] The accumulation of bone-seeking radionuclides such as Technetium-99m Methylene Diphosphonate (Tc-99m MDP) in bone lesions is primarily dependent upon blood flow and on non-metabolic exchange processes between normal constituents of the hydroxyapatite-crystalline structure and the radionuclides. The osteoid osteoma has a large vascular supply and a higher than normal number of osteoblasts. It avidly takes up MDP. Patients are injected with Tc-99m MDP; since the agent is blood borne, it reflects blood flow to the osteoma site. It also adsorbs onto the hydroxyapatite crystal. Its concentration is proportional to osteoblastic activity.[12] The purpose of the study was to evaluate role of Tc-99m MDP Bone Scan (BS) to locate the active osteoid osteoma at varied locations.

METHODS

A retrospective observational study was conducted on 21 patients (15 males and 6 females) that were referred to Nuclear Medicine departments with suspicion of osteoid osteoma during the period of Jan 2010 to Jan 2017. The radiological investigations such as X ray or CT showed sclerotic lesions with suspicion of osteoid osteoma.

They were injected intravenously 10-20mCi (370 to 740MBq) of Tc-99m MDP and dynamic images of affected bone and delayed static images after 3 hours were acquired under the dual head Gamma Camera. Single Photon Emission Computer Tomography/ Computer Tomography (SPECT/CT) images were acquired for better localization of lesion.

The images were studied by experienced Nuclear Medicine Physician to look for perfusion at suspected osteoma site and uptake of Tc-99m MDP at the lesion site. The increased perfusion and delayed focal increased uptake was considered as positive for osteoid osteoma. The ‘double density sign’ as seen by increased uptake in the sclerotic margin and cold area in the nidus was looked for. SPECT/CT was studied to localise the focal increase uptake area with area of sclerosis or nidus on corresponding CT slice. 8 patients underwent follow-up BS minimum of 3 weeks after Radio-frequency ablation (RFA) therapy. The reduced perfusion and uptake on delayed BS was considered as favourable response to RFA.

The correlation with presentation and findings on BS were compared with visualization of nidus on CT scan. The statically significance was determined using 5% confidence limit.

RESULTS

Mean age of the group was 25.8 yrs. The location of lesions was in femur, vertebrae, forearm bones, humerus, tibia, fibula and iliac bones (Table 1). The neck and trochanter of femur was seen to be the most common site of osteoid osteoma followed by vertebrae in the study group.

Table 1: Anatomical distribution of location of osteoid osteoma.

Location	No.	Percentage
Femur	9	42.85%
Vertebrae	4	19.04%
Humerus	2	9.52%
Forearm Bones (ulna and radius)	2	9.52%
Iliac bone	1	4.76%
Tibia	2	9.52%
Fibula	1	4.76%
Total	21	

The 10 (47%) patients had typical pain representing osteoid osteoma at suspected site such as focal pain with aggravation at night and relived by oral salicylate. However, remaining 11 (53%) patients presented with atypical pain such as dull pain with no specific aggravating or reliving factors. Five patients with lesions in fibula, humerus and forearm bones had focal pain and were being treated as post-traumatic or stress fractures before diagnosis.

The nidus was visualized in 13 (61.9%) patients on CT. CT demonstrated nidus in 8/9 (88%) patients with osteoid osteoma in femur; however only 1/4 (25%) in vertebrae and 1/2 (50%) in forearm bones, tibia and humerus (Table 2). All these patients showed focal cortical thickening. BS ruled out possibility of Osteoid osteoma in 1/9 lesions in femur, 1 lesion in forearm and tibia each. There was no evidence of increased flow and focally increased uptake in delayed cortical images in these patients. The McNemar test showed no significant

difference (p=0.22) in the detection of osteoid osteoma using CT and BS in common location of femur. However, there was significant difference noted between BS and CT to detect osteoid osteoma in uncommon site (p=0.023) e.g. vertebrae and forearm bones. BS detected more lesions (18) than CT scan where nidus as confirmatory sign was seen in 13 lesions. BS additionally ruled out osteoid osteoma in 3 patients. SPECT/CT improved the detection of lesion on BS for all the locations such as pedicle of vertebra (Figure 1), head of humerus (Figure 2), shaft of radius (Figure 3), iliac bone (Figure 4), shaft of fibula (Figure 5).

Table 2: Comparison of BS and CT for detection of osteoid osteoma.

Region	BS		CT-visualization of nidus	
	positive	Negative	Yes	No
Femur = 9	8	1	8	1
Spine = 4	3	1	1	3
Forearm bones =2	1	1	1	1
Iliac bone =1	1	0	0	1
Humerus = 2	2	0	1	1
Tibia = 2	2	0	1	1
Fibula =1	1	0	1	0

BS: Bone Scan, CT: Computer Tomography

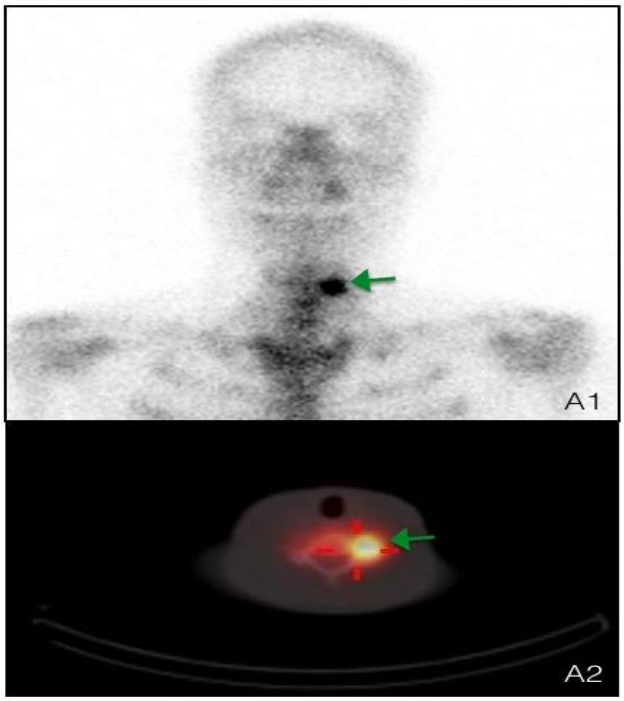

Figure 1: Anterior view of delayed cortical. (A1) SPECT/CT fusion transaxial image, (A2) showing osteoid osteoma in left pedicle of C4 vertebra (green arrow).

There were 8 patients who underwent follow up bone scan 3/8 patients (2 lesions in femur and one in tibia) showed persistent increased delayed activity corresponding to the lesion on BS (Table 3). These patients showed clinically persistent pain suggesting inadequate response to RFA. There was reduced perfusion and delayed cortical uptake in 5/8 patients suggesting favourable response to RFA ablation (Figure 6).

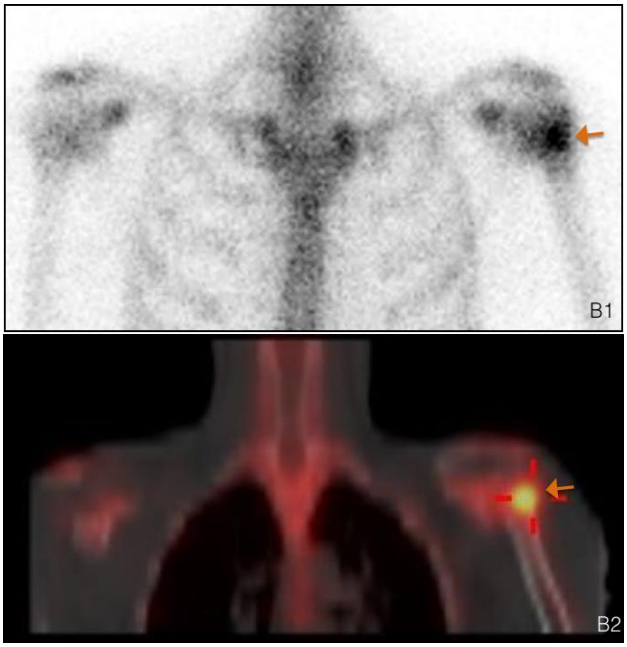

Figure 2: Anterior static image (B1) of BS and coronal image of SPECT/CT (B2) showing osteoid osteoma in head of left humerus (orange arrow).

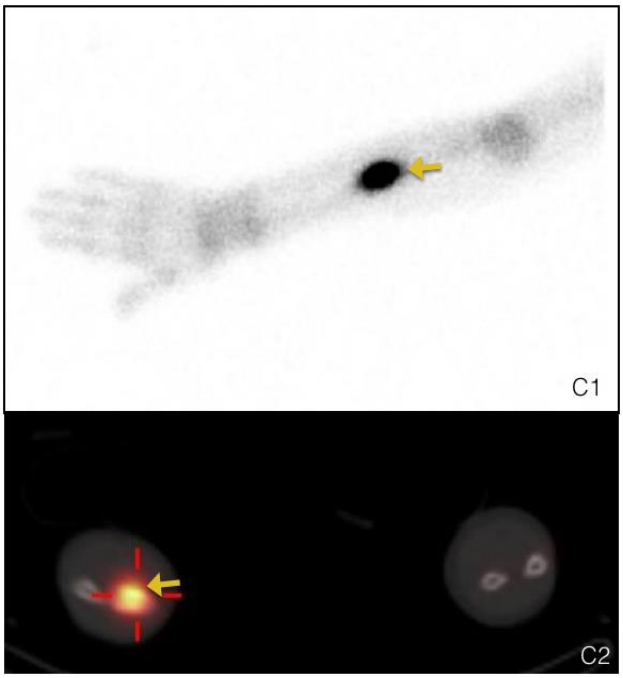

Figure 3: Anterior static image (C1) of right forearm and SPECT/CT transaxial fusion image (C2) showing osteoid osteoma in mid- shaft of right radius (yellow arrow).

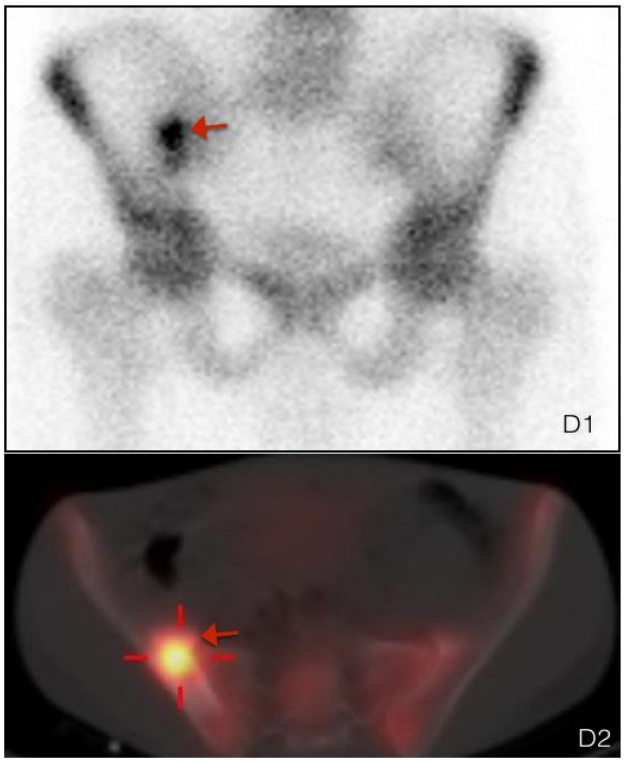

Figure 4: Anterior static image (D1) of pelvis on BS and SPECT/CT transaxial fusion image (D2) showing osteoid osteoma in iliac bone on right (red arrow).

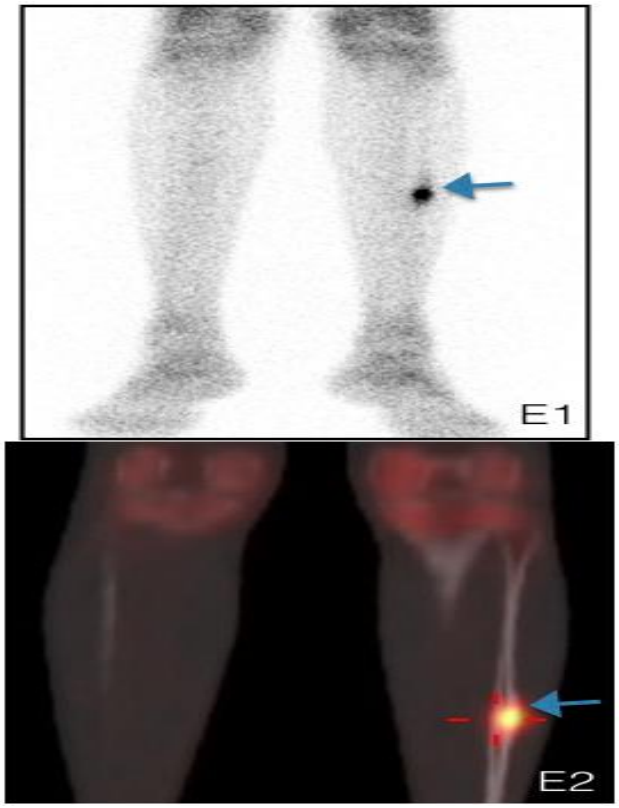

Figure 5: Anterior static image (E1) of legs on BS and SPECT/CT coronal fusion image (E2) Osteoid osteoma in mid-shaft of left fibula (blue arrow).

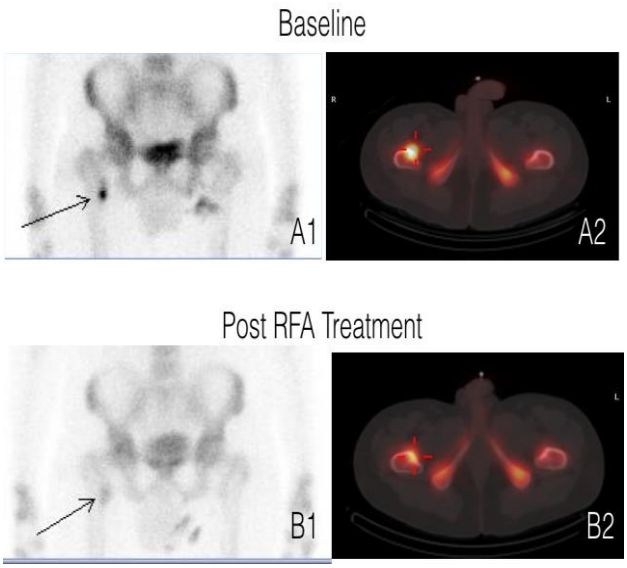

Figure 6: Bone Scan showing active osteoid osteoma (arrow) in lesser trochanter of right femur (A1-delayed cortical and A2- SPECT/CT images) showing favourable response to RFA (B1-delayed cortical and B2- SPECT/CT images) as seen by reduced cortical activity post RFA.

Table 3: Response assessment using BS after RFA11.

Location	No. of cases	Response to RFA using BS/SPECT-CT	
		Resolution of osteoid osteoma	Persistent active osteoid osteoma
Femur	7	5	2
Tibia	1	0	1

SPECT-CT: Single Photon Emission Tomography-Computer Tomography, CT: Computer Tomography, RFA: Radio Frequency Ablation, BS: Bone scan

DISCUSSION

In plain radiographs the lesion is characterized by a small nidus surrounded by dense bone.[5] The nidus is mostly seen as a radiolucent area not more than 5mm in diameter, significantly or mildly calcified depending on the disease duration.

Park J H et al, concluded that 28.6% of osteoid osteoma cases with clinical indications revealed no abnormal findings in plain radiographs. However, all radionuclide imaging results in the present study accurately identified positive cases of osteoid osteoma.[4] In our study, group nidus was visualised in 61.9% of patients; however BS improved detection of lesions in 85.7% patients.

Heshemi J et al, mentioned that the medullary type involves the neck of the femur, vertebra and small bones. This type, due to formation of osteosclerosis at a distant point, is unable to cause peripheral reactive bone formation. If no reactive bone formation is present,

detection of the nidus may be difficult, especially in the spinal column and femoral neck. In such a case radionuclide bone scan may be helpful.[5,10,11] Generally, compared to MRI, CT scan is more specific for spotting a nidus. Signals in MR imaging differ among bone marrow edema, nidus and soft tissue.[13] Nonetheless, the nidus is of predominantly intermediate signal intensity on T1-weighted images and of intermediate to high signal intensity on T2- weighted images.[14]

If no reactive bone is apparent, the nidus may be difficult to detect, and radionuclide scans are helpful in identifying the lesion.[10] Spotting the double- density sign on radionuclide bone scans is diagnostic for osteoid osteoma and helps in localizing the nidus. It is also helpful to differentiate between the nidus of an osteoid osteoma and osteomyelitis.[11] Villani MF et al, demonstrated Bone scintigraphy in children showed lesions in 53/53 patients, of whom 51 patients had a typical pattern of osteoma and nine patients required an additional scan with a pinhole collimator. In the event of ambiguous or negative radiographic results, bone scintigraphy is needed to exclude other pathologic conditions and to confirm the diagnosis.[15]

SPECT helps in locating nidus that is seen as double density sign.[16] In our study, SPECT/CT additionally helped to confirm the localization of lesion especially in vertebrae and close to femoral growth plate in children. The double density sign was not a common feature on BS. Our study ruled out osteoid osteoma in 3 patients by showing absence of increased perfusion and delayed cortical reaction; changing the management. BS performed better to confirm the diagnosis in the uncommon locations where visualisation of nidus was not possible on CT scan.

The Osteoid osteoma is treated by RFA and the CT demonstrates no significant change in the appearance of the lesion. The clinical successes in most series reporting on primary RFA for Osteoid Osteoma varied between 73-95%.[17] Kulkarni SS et al, mentioned that PET/CT using F-18 and fluorodeoxy glucose may have role in the diagnosis and post-treatment response evaluation. The nidus exhibits avid glucose metabolism, whereas surrounding sclerosis does not.[18-20] However, in our study BS using Tc-99m MDP also helped to assess the response to RFA therapy in 8 patients.

CONCLUSION

The BS performed better in detection of osteoid osteoma in uncommon location such as vertebrae, forearm bones, tibia and fibula where visualisation of nidus is not very clear. If the plain radiograph was equivocal, tomography should be directed to the area in question, whereas if the plain radiograph and CT is not conclusive with high index of suspicion for osteoid osteoma, radionuclide imaging such as BS should be performed. BS is also helpful to rule out osteoid osteoma due to high negative predictive value. BS also helped to assess response to RFA therapy.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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