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Diagnostic edge of SPECT/CT scintigraphy over planar bone imaging for detection of bone metastases in prostate cancer patients

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ABSTRACT

Background: Bone scintigraphy with ^{99m}Tc-labelled diphosphonates can identify prostate cancer (PCa) bone metastases with high sensitivity but relatively low specificity. Single photon emission computed tomography /computed tomography (SPECT/CT) can add value to the planar bone scintigraphy in the detection of bone metastases.

Case Presentation: We present a diagnosed case of prostatic adenocarcinoma of a 62 years old male patient who underwent ^{99m}Tc-Methyldiphosphonate planar bone scintigraphy followed by SPECT/CT as a part of the staging algorithm. Planar bone imaging showed homogeneous and symmetrical tracer uptake throughout the visualized skeleton. As the patient had complaints of urinary obstruction and severe backache: so, the sacrum could not be adequately assessed on planar bone imaging; therefore SPECT/CT of the lumbar spine and the pelvic region was performed. His regional SPECT-CT study of the lumbar and pelvic region, revealed widespread diffuse tracer avid osteoblastic lesions throughout the visualized lower lumbar spine, sacrum, pelvis, and proximal femori, suggestive of skeletal metastases.

Conclusion: We conclude that SPECT/CT scintigraphy has a diagnostic edge over planar bone imaging in detecting bone metastases in PCa patients.

Keywords: SPECT/CT, planar bone scan, prostate cancer, equivocal lesions, case report.

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Introduction

Prostate carcinoma is the most commonly diagnosed cancer among men above the age of 50 years [1]. Generally, such patients have a 5-year survival rate of 98% but this incidence decreases quickly with the diagnosis of distant metastases. The most common site for distant metastases is the skeletal system and nearly 85% of patients with fatal prostate cancer (PCa) show bone metastases [2]. Skeletal metastases are associated with significant morbidity and skeletal-related events. Hence, the detection of bone metastases in cancer patients is essential for accurate diagnosis and proper patient management [3].

In a clinical workflow, a bone scan is the most common and cost-effective modality for the diagnosis of bone metastases [2]. It is relatively inexpensive and allows whole-body screening. Moreover, it is highly sensitive in the detection of malignant bone lesions but due to non-specific bone uptake related to osteoblastic activity; it has relatively low specificity and hence potentially leads to false positive

results, especially in case of degenerative diseases, trauma, and inflammation. Due to its low specificity, its diagnostic effectiveness has been widely questioned in literature. False positive scintigraphic findings necessitate additional radiological imaging, mainly plain radiographic images. However, the correlation between X-ray or even computerized tomographic (CT) images and bone scintigraphic images remains challenging, and in many cases, exact anatomical localization cannot be confidently ascertained. Single photon emission computed tomography (SPECT/CT) system combines the functional benefit of SPECT with anatomical information of CT in a single setting, allowing optimum co-registration of both functional and anatomical images and could be accepted for accurately evaluating suspected bone metastases. Studies have shown that the number of unclear or equivocal lesions detected in whole-body planar scintigraphy and SPECT can be significantly decreased using SPECT/CT. CT component leads to better

anatomic localization as well as characterization of lesions and SPECT part results in higher lesion to back-ground contrast as compared to a planar bone scan. Moreover, SPECT/CT has been shown to increase the accuracy of bone scanning for the detection of bone metastases and significantly impacts the clinical management decisions of cancer patients [4,5].

Case Presentation

A 62 years old male, diagnosed case of prostatic adenocarcinoma was referred to the Nuclear Medicine department of INMOL for ^{99m}Tc -Methyldiphosphonate (MDP) planar bone scintigraphy as a part of the staging algorithm. He complained of severe backache and urinary obstruction. Histopathology of trans-urethral resection of prostate (TURP) revealed prostatic adenocarcinoma having Gleason's Score (GS) $4 + 5 = 9$. Ultrasonography (USG) showed enlarged prostate with a weight of 51 gm, along with bilateral hydronephrosis and hydroureter. His serum prostate-specific antigen (PSA) was 37.7 ng/ml. His renal function tests (RFTs) deteriorated with elevated serum creatinine (2.0 mg/dl) and serum urea (63 mg/dl). His liver function tests (LFTs) revealed markedly raised alkaline phosphatase (286 U/l). In the nuclear medicine department, his ^{99m}Tc -MDP planar bone scan was carried out. ^{99m}Tc -MDP planar bone scan images showed homogenous and symmetrical tracer distribution throughout the axial and appendicular skeleton (Figure 1). However, the sacrum could not be adequately assessed due to superimposition of the bladder as the patient was unable to

evacuate the bladder due to a complaint of urinary obstruction. Moreover, the patient had complaints of severe low backache and it was decided to proceed with SPECT/CT of the lumbar spine and pelvic region. SPECT/CT images of the lumbar spine and pelvis, revealed widespread diffuse osteoblastic lesions throughout the visualized lower lumbar spine, sacrum, pelvis, and proximal femori with diffuse tracer uptake (Figures 2–5), thus suggesting widespread skeletal metastases. Later on, his non-contrast Magnetic resonance imaging (MRI) pelvis suggested residual/recurrent disease in the prostate, along with confirmation of osseous metastases. All the lab results and imaging studies of the patient are enlisted in Table 1.

Discussion

Standard initial local treatment for the patients of PCa may include watchful waiting, radiation therapy and radical prostatectomy. Therefore, accurate initial staging and detection of bone metastases is essential for treatment planning and patient prognosis.

Osteoblastic metastases are most often associated with prostate and breast cancer [6]. ^{99m}Tc -labelled diphosphonates are non specific markers of osteoblastic activity which are also observed in benign conditions including fractures, Paget's disease, degenerative joint diseases, trauma, and inflammation [4].

A major disadvantage of planar bone scan is its low specificity due to tracer accumulation in bone lesions of non-neoplastic etiology which frequently results in considerable number of indeterminate or non-conclusive lesions on planar bone scans. This leads to more correlative imaging tests (typically CT or MRI) and/or more frequent follow-up visits, resulting in additional cost and patient inconvenience. It is well documented that SPECT has better accuracy than planar bone scan and SPECT/CT has better accuracy than SPECT alone. Integrated SPECT-CT system is a well-established imaging modality providing precise anatomical localization and better characterization of suspicious osseous lesions detected in planar bone scintigraphy by combining the functional benefit of SPECT with anatomical information of CT in a single setting, saving time and money. SPECT/CT images help to differentiate benign lesions from malignant lesions, therefore, decreasing the number of equivocal lesions resulting in optimal the patient management [4,5].

Rager et al. [7] showed increased sensitivity and specificity of whole body SPECT/CT for detection of bone metastases as 97% and 94% respectively.

Tabotta et al. [8] used quantification to differentiate PCa metastases from spinal and osteoarthritic changes, thereby reporting an increase in the accuracy of SPECT/CT.

Tuncel et al. [9] conducted a study in 210 patients of cancer patients (including PCa) and concluded that SPECT/CT is a revolutionary technique that improved the interpretation of bone scan by recognition of patterns of disease.

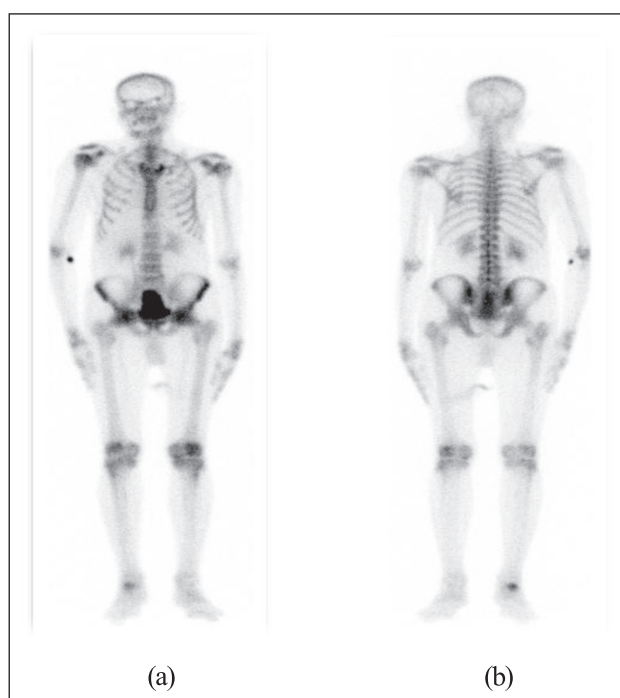


Figure 1. (a,b) Anterior and posterior planar whole body images showing bilateral homogenous and symmetrical tracer uptake in the axial and appendicular skeleton.

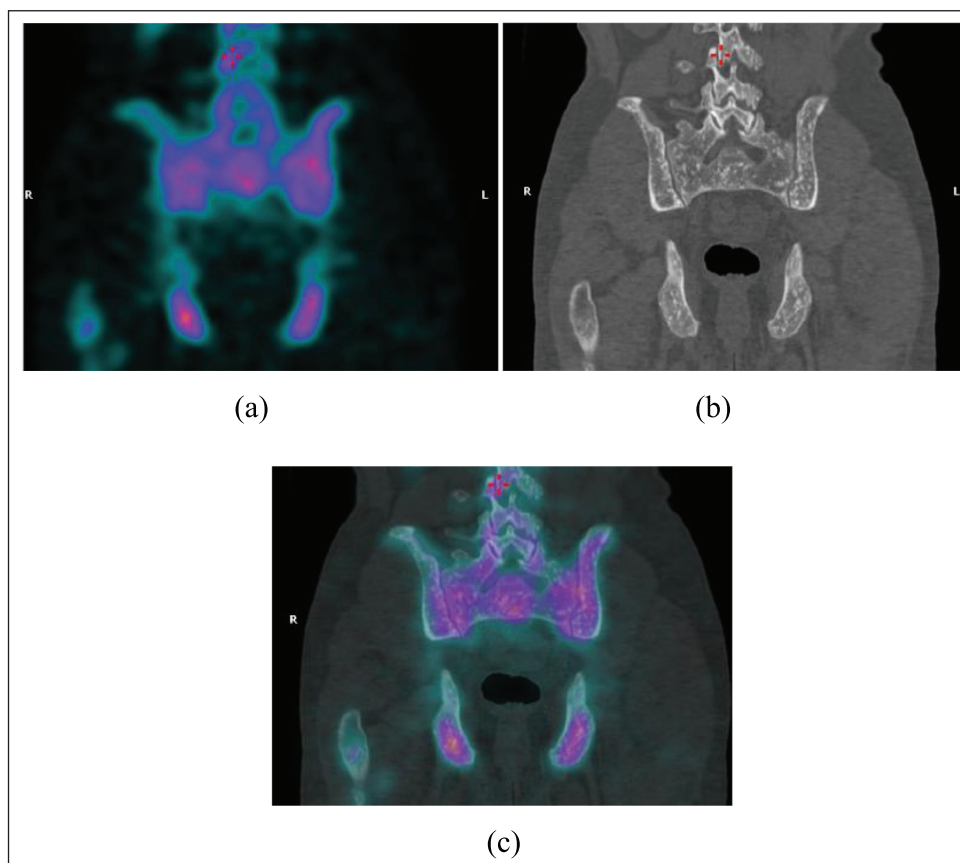


Figure 2. (a–c) SPECT, CT and fused SPECT/CT images of coronal slices of lumbar spine and femori showing diffuse osteoblastic lesions with diffuse tracer uptake.

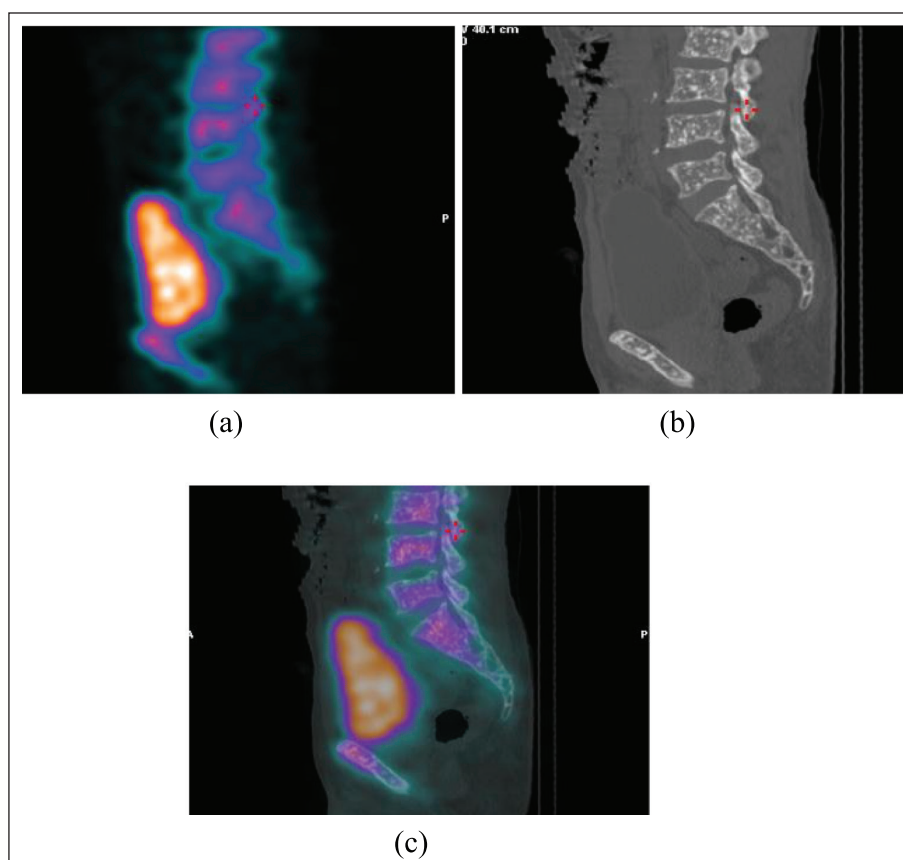


Figure 3. (a–c) SPECT, CT and fused SPECT/CT images of sagittal slices of lumbar spine and sacrum showing diffuse osteoblastic lesions with diffuse tracer uptake.

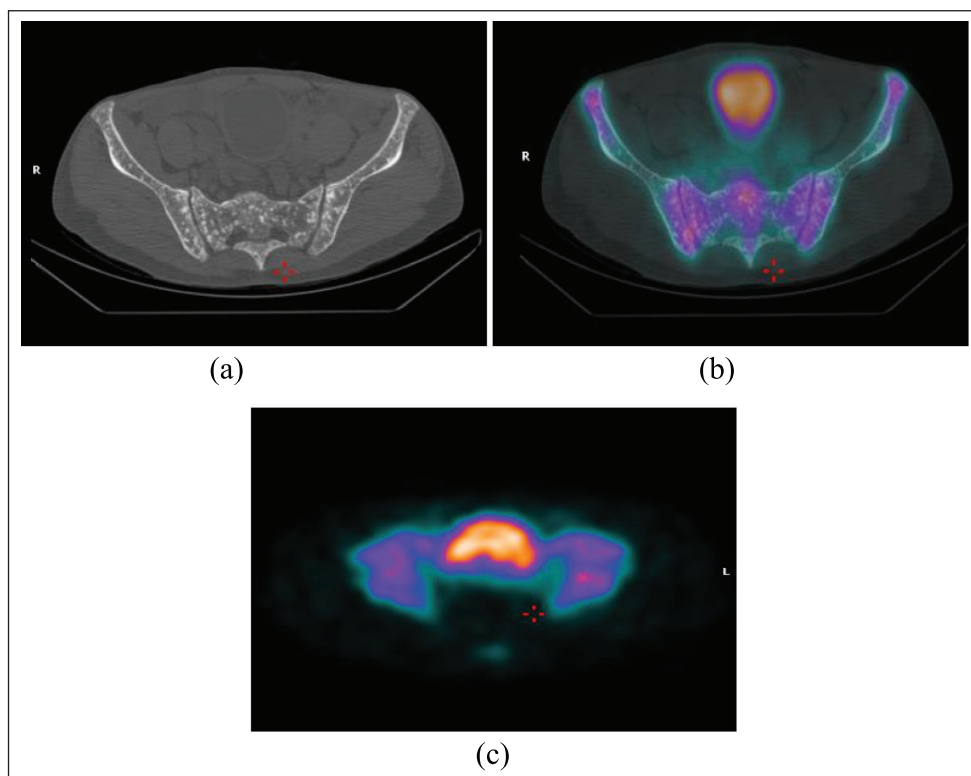


Figure 4. (a–c) SPECT, CT and fused SPECT/CT images of axial slices of iliac bones and sacrum showing diffuse osteoblastic lesions with diffuse tracer uptake.

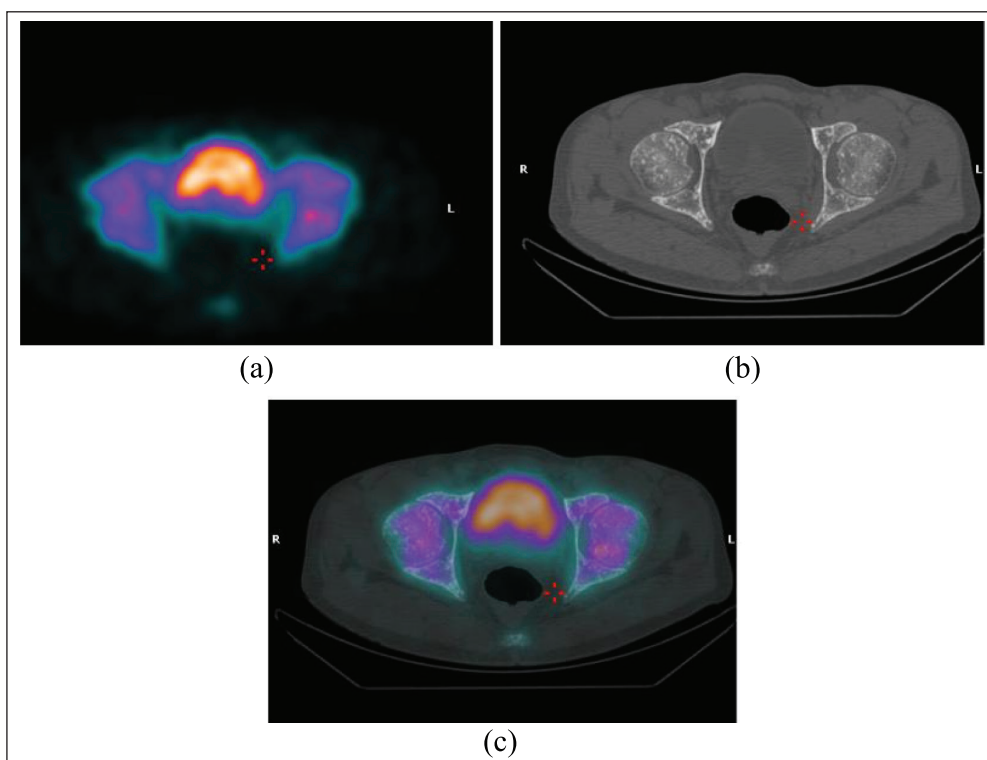


Figure 5. (a–c) SPECT, CT and fused SPECT/CT images of axial slices of femoral heads showing diffuse osteoblastic lesions with diffuse tracer uptake.

Table 1. Lab results and imaging studies of the patient.

Histopathology (TURP)	Lab tests			Imaging studies			
	RFTs mg/dl	LFTs U/l	PSA ng/ml	USG	MRI	Planar bone scan	SPECT/CT of Spine & pelvis
Prostatic adenocarcinoma GS 4 + 5 = 9 peri-neural invasion tumor load: 75%–80% no extra-prostatic invasion and lympho-vascular invasion	S. Creatinine 2.0 S. Urea 63	Alkaline phosphatase 286	37	Enlarged prostate (43 × 45 × 49 mm) Weight (51 gm) Bilateral hydro-nephrosis & hydrourter	Residual/recurrent disease, along with osseous metastases bilateral hydro-urter secondary to chronic bladder outflow obstruction	Homogenous & symmetrical tracer uptake throughout skeleton	Diffuse osteo-blastic lesions of visualized skeleton with diffuse tracer uptake

Montilla-Sollaer and Makanji [10] concluded in their study that skeletal scintigraphy has a significant role in the initial diagnosis, staging, restaging, and treatment monitoring of patients with cancer and primary skeletal or metastatic disease but the coupling of diagnostic and therapeutic nuclear medicine agents in the setting of osteoblastic skeletal metastases is a valuable tool for certain cancer types, including PCa.

Our case report is in congruence with the above-mentioned study results of SPECT/CT provides better diagnostic accuracy than ^{99m}Tc-planar bone scintigraphy in the detection of bone metastases by detecting the diffuse osteoblastic lesions on SPECT/CT that were missed on planar bone scintigraphy images.

Conclusion

Skeletal SPECT/CT scintigraphy offers an important diagnostic advantage over planar bone imaging for the detection and characterization of osseous lesions in PCa patients, especially in cases of equivocal lesions or unexplained symptoms along with the inability to focus on certain regions of the skeleton.

List of Abbreviations

CT	Computed tomography
GS	Gleason's Score
LFTs	Liver function tests
MDP	Methyldiphosphonate
MRI	Magnetic resonance imaging
PCa	Prostate carcinoma
RFTs	Renal function tests
SPECT	Single photon emission computed tomography
SPECT/CT	Single photon emission computed tomography/computed tomography
TURP	Trans-urethral resection of prostate
USG	Ultrasonography

Conflict of interests

The authors declare no conflict of interest regarding the publication of this article.

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Consent for publication

Informed consent was obtained from the patient for the publication of this case.

Ethical approval

Ethical approval is not required at our institution for publishing a case report in a medical journal.

Author's contribution

All authors contributed to drafting, revising and final editing of manuscript.

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