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Original article

Comparative Study of Tc-99m MDP Bone Scan and MRI in Detection of Skeletal Metastasis in Breast Cancer Patients

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ABSTRACT

Background - *Skeletal metastasis is a common complication in breast cancer and significantly affects morbidity, quality of life, and survival. Early and accurate detection of bone metastasis is essential for staging, treatment planning, and prognosis. Tc-99m MDP bone scintigraphy and Magnetic Resonance Imaging (MRI) are widely used imaging modalities for detecting skeletal metastases. Bone scintigraphy provides whole-body screening, while MRI offers superior soft tissue contrast and marrow evaluation.*

Materials and Methods- *This prospective comparative study included 70 histopathologically confirmed breast cancer patients suspected of skeletal metastasis. All patients underwent Tc-99m MDP bone scintigraphy and MRI evaluation. Imaging findings were compared with clinical follow-up, radiological correlation, and histopathological findings where available. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of both modalities were calculated.*

Results- *Among 70 patients, skeletal metastases were confirmed in 42 patients. Tc-99m MDP bone scan detected metastases in 38 patients, while MRI detected metastases in 41 patients. MRI demonstrated higher sensitivity (95.2%) compared to bone scan (88.1%). MRI also showed superior specificity (89.3%) compared to bone scan (78.6%). Vertebral involvement was the most common metastatic site. MRI was particularly superior in detecting early marrow infiltration and spinal lesions.*

Conclusion- *MRI demonstrated superior diagnostic performance compared to Tc-99m MDP bone scintigraphy in detecting skeletal metastases in breast cancer patients. However, bone scan remains valuable as an economical whole-body screening tool in resource-limited settings. Combined use of both modalities may improve diagnostic accuracy.*

Keywords- *Breast cancer; Skeletal metastasis; Tc-99m MDP bone scan; MRI; Bone scintigraphy.*

INTRODUCTION

Breast cancer is the most common malignancy among women worldwide and remains a leading cause of cancer-related mortality. Bone is one of the most frequent sites of distant metastasis in breast cancer patients. Approximately 65–75% of patients with advanced breast cancer develop skeletal metastases during the course of disease. Early detection of bone metastasis is essential because it significantly influences staging, therapeutic planning, prognosis, and quality of life.

Skeletal metastases commonly involve the vertebral column, pelvis, ribs, skull, and proximal long bones. Bone involvement can lead to severe complications such as pathological fractures, spinal cord compression, hypercalcemia, and debilitating pain. Accurate imaging plays a critical role in identifying metastatic lesions at an early stage.

Tc-99m methylene diphosphonate (MDP) bone scintigraphy is one of the most widely used imaging techniques for screening skeletal metastases. Bone scans detect areas of increased osteoblastic activity and provide whole-body skeletal evaluation. Bone scintigraphy is relatively inexpensive, widely available, and highly sensitive for detecting osteoblastic lesions. However, its specificity is limited because benign conditions such as trauma, arthritis, infection, and degenerative changes may also demonstrate increased tracer uptake.

Magnetic Resonance Imaging (MRI) has emerged as a highly sensitive imaging modality for detecting bone marrow metastases. MRI can identify metastatic infiltration before cortical destruction or osteoblastic reaction becomes evident on bone scintigraphy. MRI offers excellent soft tissue contrast and superior evaluation of spinal and marrow lesions. It is especially useful for assessing vertebral metastases and spinal cord compression.

Despite advancements in imaging techniques, controversy persists regarding the optimal imaging modality for detection of skeletal metastases in breast cancer patients. In developing countries, cost-effectiveness and

accessibility also influence imaging selection. Comparative evaluation of bone scintigraphy and MRI may help clinicians choose appropriate diagnostic strategies in different clinical settings.

The present study was conducted to compare Tc-99m MDP bone scintigraphy and MRI in the detection of skeletal metastases among breast cancer patients and to evaluate the diagnostic performance of both modalities.

MATERIALS AND METHODS

Study Design

Prospective comparative study.

Study Setting

The study was conducted in the Department of Nuclear Medicine and Department of Radiodiagnosis at a tertiary care teaching hospital.

Study Duration - Two years

Study Population

Histopathologically confirmed breast cancer patients clinically suspected of skeletal metastasis were included in the study.

Sample Size

A total of 70 patients were included.

Inclusion Criteria

1. Histopathologically confirmed breast carcinoma.
2. Patients with clinical suspicion of skeletal metastasis.
3. Patients willing to participate in the study.
4. Age above 18 years.

Exclusion Criteria

1. Patients with prior skeletal malignancy.
2. Contraindications to MRI.
3. Pregnant patients.
4. Patients with incomplete imaging evaluation.

Imaging Protocol

Tc-99m MDP Bone Scan

Whole-body bone scintigraphy was performed using Tc-99m methylene diphosphonate. Images were acquired 3 hours after intravenous injection of radiotracer using a dual-head gamma camera.

MRI Evaluation

MRI examinations were performed using a 1.5 Tesla MRI system. T1-weighted, T2-weighted, STIR, and contrast-enhanced sequences were obtained depending on lesion location.

Data Collection

The following data were recorded:

- Age
- Tumor stage
- Histopathological subtype
- Presence of bone pain
- Site of metastasis
- Bone scan findings
- MRI findings
- Final diagnosis based on follow-up and correlation

Outcome Measures

1. Sensitivity
2. Specificity
3. Positive predictive value
4. Negative predictive value
5. Diagnostic accuracy

Statistical Analysis

Data were analyzed using SPSS version 25. Continuous variables were expressed as mean ± standard deviation. Sensitivity, specificity, PPV, NPV, and diagnostic accuracy were calculated. Chi-square test was used for comparison between imaging modalities. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: Demographic Characteristics

Variable	Frequency	Percentage
Age 31–40 years	12	17.1%
Age 41–50 years	26	37.1%
Age 51–60 years	22	31.4%
Age >60 years	10	14.3%
Female	70	100%
Stage II disease	18	25.7%
Stage III disease	34	48.6%
Stage IV disease	18	25.7%
Bone pain present	50	71.4%

Most patients belonged to the 41–50 years age group. Stage III disease was most common.

Table 2: Distribution of Skeletal Metastatic Sites

Site	Frequency	Percentage
Vertebrae	24	57.1%
Pelvis	18	42.9%
Ribs	14	33.3%
Femur	10	23.8%
Skull	6	14.3%
Humerus	5	11.9%

Vertebral metastasis was the most common skeletal site.

Table 3: Comparison of Tc-99m MDP Bone Scan and MRI

Parameter	Bone Scan	MRI
True Positive	37	40
False Positive	6	3
True Negative	22	25
False Negative	5	2
Sensitivity	88.1%	95.2%
Specificity	78.6%	89.3%
PPV	86.0%	93.0%
NPV	81.5%	92.6%
Diagnostic Accuracy	84.3%	92.9%

MRI demonstrated higher sensitivity, specificity, and diagnostic accuracy compared to Tc-99m MDP bone scintigraphy.

Table 4: Comparative Detection of Specific Lesions

Lesion Type	Bone Scan Detection	MRI Detection
Vertebral marrow lesions	18	24
Early marrow infiltration	10	20
Cortical lesions	22	21
Spinal cord compression	2	8
Small pelvic lesions	9	15

MRI was superior in detecting marrow infiltration and spinal cord compression.

DISCUSSION

Bone metastasis represents a major cause of morbidity in breast cancer patients and significantly influences survival and quality of life. Early detection of skeletal metastasis allows timely therapeutic intervention and prevention of skeletal-related events such as fractures and spinal cord compression.

In the present study, MRI demonstrated superior sensitivity and specificity compared to Tc-99m MDP bone scintigraphy. MRI showed excellent ability to detect early marrow infiltration before development of osteoblastic changes. These findings are consistent with previous studies that reported MRI as highly sensitive for early metastatic marrow disease.

Bone scintigraphy remains one of the most commonly used modalities for screening skeletal metastases due to its whole-body imaging capability and relatively low cost. However, false-positive uptake caused by degenerative changes, fractures, and inflammatory lesions limits specificity. In our study, six false-positive bone scan findings were observed, mainly due to degenerative spinal changes.

MRI showed significantly better detection of vertebral lesions and spinal cord compression. Vertebral metastasis was the most common metastatic site in our study, similar to previously published literature. MRI is especially advantageous in evaluating spinal involvement because it provides excellent soft tissue contrast and detailed assessment of neural structures.

Early marrow infiltration lesions were better visualized on MRI than bone scintigraphy. Bone scan relies on osteoblastic activity for lesion detection, whereas MRI directly visualizes marrow replacement. Therefore, purely lytic or early marrow lesions may be missed on bone scintigraphy.

The diagnostic accuracy of MRI in the present study was 92.9%, compared to 84.3% for bone scintigraphy. Similar findings have been reported by Lecouvet et al. and Eustace et al., who demonstrated higher accuracy of MRI for skeletal metastasis detection.

Despite the superior performance of MRI, bone scintigraphy continues to play an important role in developing countries. Bone scan provides rapid whole-body skeletal assessment at lower cost and greater availability. MRI may not be feasible as a primary screening tool in all patients due to financial limitations and limited accessibility.

The combined use of both imaging modalities may provide complementary information. Bone scan is useful for screening, while MRI can further characterize suspicious lesions and evaluate spinal involvement. Hybrid imaging techniques such as PET/CT and PET/MRI are increasingly utilized but remain costly in many developing nations.

The study highlights the importance of selecting imaging modalities based on clinical scenario, resource availability, and diagnostic requirements. Patients with neurological symptoms, equivocal bone scan findings, or suspected spinal metastasis particularly benefit from MRI evaluation.

CONCLUSION

MRI demonstrated superior sensitivity, specificity, and diagnostic accuracy compared to Tc-99m MDP bone scintigraphy in detecting skeletal metastases in breast cancer patients. MRI was particularly effective for early marrow infiltration, vertebral metastases, and spinal cord compression. However, Tc-99m MDP bone scan remains an economical and valuable whole-body screening tool in resource-limited settings. Combined use of both modalities may optimize detection and management of skeletal metastases.

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