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COMPARISON BETWEEN COMPUTED TOMOGRAPY AND BONE SCINTIGRAPHY FOR EVALUTION OF BONE METASTASES FROM BREAST CANCER

Original Research

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ABSTRACT

Background: Breast cancer is a leading malignancy among women worldwide, frequently metastasizing to the bones, leading to significant morbidity. Accurate detection of bone metastases is crucial for optimal management and treatment decisions. Computed tomography (CT) and bone scintigraphy (BS) are widely used imaging modalities, each with distinct advantages. While CT provides detailed structural visualization, BS offers higher sensitivity in detecting early metastatic involvement. This study aimed to compare the diagnostic accuracies of CT and BS in detecting bone metastases in breast cancer patients.

Objective: To assess the prevalence and severity of breast cancer bone metastases using CT and BS across different age groups and determine the most effective imaging modality for early detection.

Methods: A descriptive cross-sectional study was conducted at the Institute of Nuclear Medicine & Oncology Lahore (INMOL) Hospital, including 158 female participants recruited through purposive sampling. Participants were stratified into three age groups: 30–45 years, 45–60 years, and above 60 years. Clinical symptoms, CT findings, and BS findings were analyzed over four months. CT scans assessed bone metastases, lesion characteristics, and breast tissue abnormalities, while BS evaluated osteoblastic and osteolytic changes. Chi-square analysis was performed to determine associations between clinical symptoms and imaging findings.

Results: Among 158 participants, 58 (36.7%) were aged 30–45 years, 80 (50.6%) were 45–60 years, and 20 (12.7%) were above 60 years. Bone metastases were detected in 66 (41.8%) participants on BS and in 59 (37.3%) on CT. Osteoblastic changes were identified in 92 (58.2%), osteolytic changes in 69 (43.7%), and abnormal tracer uptake in 66 (41.8%) participants. CT imaging revealed breast abnormalities in 100 (63.3%) participants, with heterogeneous lobulated masses being the most common finding. Chi-square analysis demonstrated a statistically significant correlation between bone pain and metastatic involvement ($p < 0.001$).

Conclusion: Bone scintigraphy demonstrated superior sensitivity in detecting bone metastases compared to CT, suggesting its utility as the preferred initial imaging modality for breast cancer patients with suspected skeletal involvement. Incorporating both modalities in a multimodal diagnostic approach can enhance early detection and improve patient outcomes.

Keywords: Bone metastases, Bone scintigraphy, Breast cancer, Computed tomography, Diagnosis, Metastatic breast cancer, Skeletal involvement.

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INTRODUCTION

Breast cancer is a heterogeneous disease characterized by uncontrolled cellular proliferation in the breast, leading to tumor formation that can invade surrounding tissues and metastasize to distant sites. It often originates in the ducts or lobules and is one of the most common malignancies affecting women worldwide (1). Among its metastatic sites, the skeleton is frequently involved, with metastases categorized as osteolytic, osteoblastic, or mixed, reflecting bone degradation, excess deposition, or both processes occurring simultaneously (2,3). The presence of bone metastases significantly contributes to disease burden, leading to pain, impaired mobility, pathological fractures, hypercalcemia, and complications such as spinal cord or nerve root compression. Bone pain, a hallmark symptom of bone metastases, often manifests as a deep, aching discomfort with episodes of stabbing sensations, resulting from factors such as periosteal stretching, nerve root infiltration, muscle spasms, and the local action of cytokines (4). In the United Kingdom, breast cancer remains a major public health concern, with 48,417 women diagnosed in 2009. Advances in detection and treatment have led to improved survival rates, with age-standardized relative survival reaching 85% at five years and 77% at ten years. Despite this progress, bone metastases remain a common complication in patients with advanced disease, with the majority of breast cancer-related deaths occurring in individuals who have bone involvement at the time of death (5). Patients with bone-only metastases tend to have a more favorable prognosis compared to those with visceral involvement, with median survival reaching up to 72 months in some studies. However, survival rates vary considerably, with only 20–30% of patients expected to survive beyond five years following the diagnosis of bone metastases (6). Given the substantial morbidity associated with skeletal metastases, accurate and early detection is critical for optimizing patient outcomes.

Imaging plays a pivotal role in the diagnosis of bone metastases, with different modalities offering varying levels of sensitivity and specificity. Conventional bone scintigraphy (BS) is widely utilized due to its ability to survey the entire skeleton at a relatively low cost, making it a valuable initial screening tool (7). Computed tomography (CT), on the other hand, offers superior soft tissue and contrast resolution, enabling precise visualization of osteolytic and osteoblastic lesions as well as soft tissue extensions of metastases (8). CT is particularly useful for diagnosing spinal metastases and guiding biopsy procedures. While bone scintigraphy is effective in detecting both lytic and sclerotic bone metastases, CT provides enhanced anatomical detail, aiding in the distinction between benign and malignant lesions (9). The vertebral column is the most common site of skeletal metastases in breast cancer, followed by the ribs and sternum, with the latter often affected through direct tumor extension via the internal mammary chain (9,10). Despite the availability of these imaging techniques, there remains a gap in understanding their relative diagnostic accuracy, particularly in different age groups. A comprehensive evaluation of their specificity, sensitivity, and effectiveness in distinguishing benign from malignant bone lesions is essential to refine diagnostic protocols and improve clinical decision-making (11). This study aims to compare the imaging features and diagnostic performance of CT and BS in detecting bone metastases in breast cancer patients, with the objective of determining the most effective modality for optimizing patient care and treatment planning.

METHODS

The study employed a descriptive cross-sectional design and was conducted at the Institute of Nuclear Medicine & Oncology Lahore (INMOL) Hospital. A total of 158 female participants were recruited through a purposive sampling method to ensure the inclusion of individuals meeting the predefined clinical criteria. Eligibility criteria encompassed women presenting with clinical indications suggestive of breast malignancy, such as palpable breast masses, nipple discharge (bloody or fluid-like), or alterations in breast size or shape. Additionally, individuals with suspected bone metastases—identified based on clinical symptoms such as persistent bone pain, elevated tumor markers, or previous imaging findings suggestive of metastatic involvement on bone scintigraphy (BS) or computed tomography (CT)—were included (3,5). To allow for a comprehensive evaluation of age-related differences, participants were stratified into three distinct age groups: 30–45 years, 46–60 years, and above 60 years. The study was conducted over four months following ethical approval from the institutional review board. Informed consent was obtained from all participants prior to study enrollment, ensuring compliance with ethical research guidelines. Each participant underwent a thorough clinical evaluation based on standardized criteria to confirm eligibility, with strict adherence to inclusion and exclusion parameters to minimize potential biases.

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Imaging assessments were performed using both BS and CT to detect and characterize bone metastases. Bone scintigraphy was utilized as an initial whole-body screening tool due to its high sensitivity in identifying metastatic lesions. Computed tomography was subsequently employed to provide detailed anatomical visualization and differentiation between benign and malignant lesions. Imaging interpretations were conducted by experienced radiologists and nuclear medicine specialists to ensure diagnostic accuracy. Data collection included demographic information, clinical presentation, imaging findings, and relevant laboratory markers. Statistical analysis was carried out using appropriate software to assess the diagnostic accuracy of BS and CT in detecting bone metastases. Sensitivity, specificity, and predictive values were calculated to compare the effectiveness of both modalities. To enhance the study's validity, strict adherence to standardized diagnostic protocols and imaging criteria was maintained. Additionally, the use of purposive sampling instead of convenience sampling minimized selection bias, improving the representativeness of the findings. While histopathological confirmation of metastatic lesions was not available for all cases, imaging findings were interpreted within a multidisciplinary framework to enhance diagnostic reliability.

RESULTS

The study included 158 female participants categorized into three age groups: 58 individuals (36.7%) were aged 30–45 years, 80 participants (50.6%) belonged to the 45–60 age group, and 20 participants (12.7%) were above 60 years old. Among the clinical symptoms assessed, 108 participants (68.4%) exhibited breast skin thickening, while 50 participants (31.6%) had no such findings. Nipple discharge with blood was reported in 53 participants (33.5%), whereas 105 participants (66.5%) had no blood discharge. Fluid nipple discharge was observed in 76 participants (48.1%), while 82 participants (51.9%) had no such complaint. Bone pain was reported by 99 participants (62.7%), while 59 participants (37.3%) did not experience this symptom. Regarding computed tomography (CT) findings of the left breast, 58 participants (36.7%) had normal imaging results. Hypodense cystic lesions were observed in 21 participants (13.3%), heterogeneous cystic lesions in 20 participants (12.7%), irregular hypodense lesions in 14 participants (8.9%), heterogeneous lobulated masses in 26 participants (16.5%), heterogeneous soft tissue masses in 13 participants (8.2%), and radical mastectomy was identified in 6 participants (3.8%). In the right breast, normal CT findings were observed in 84 participants (53.2%). Hypodense cystic lesions were present in 12 participants (7.6%), heterogeneous cystic lesions in 5 participants (3.2%), irregular hypodense lesions in 17 participants (10.8%), heterogeneous lobulated masses in 31 participants (19.6%), heterogeneous soft tissue masses in 8 participants (5.1%), and radical mastectomy was noted in 1 participant (0.6%).

Assessment of CT-based bone metastasis findings indicated that 59 participants (37.3%) exhibited metastatic lesions, whereas 99 participants (62.7%) had no metastatic involvement. On bone scintigraphy, osteoblastic changes were detected in 92 participants (58.2%), while 66 participants (41.8%) had no osteoblastic changes. Osteolytic changes were observed in 69 participants (43.7%), while 89 participants (56.3%) had no osteolytic findings. The presence of bone metastases on scintigraphy was confirmed in 66 participants (41.8%), while 92 participants (58.2%) had no metastatic involvement. Comparison of all diagnostic findings revealed that 92 participants (58.2%) had benign conditions with no bone metastases, while 66 participants (41.8%) were diagnosed with malignant disease with confirmed bone metastases. The analysis of the study data revealed key clinical and imaging findings associated with breast cancer and its metastatic spread. Among the 158 participants, the highest proportion (50.6%) belonged to the 45–60 age group, followed by 30–45 years (36.7%) and above 60 years (12.7%). Breast skin thickening was observed in 108 participants (68.4%), while nipple discharge with blood and fluid was reported in 53 (33.5%) and 76 (48.1%) participants, respectively. Bone pain, a significant indicator of potential metastases, was experienced by 99 participants (62.7%), correlating with the detection of bone metastases on CT in 59 participants (37.3%) and on bone scintigraphy in 66 participants (41.8%).

Comparing imaging modalities, osteoblastic changes on bone scintigraphy were detected in 92 participants (58.2%), while osteolytic changes were found in 69 participants (43.7%). A notable association was observed between bone pain and imaging-confirmed bone metastases, suggesting that clinical symptoms align with radiological findings. The final diagnosis indicated that 92 participants (58.2%) had benign conditions, whereas 66 participants (41.8%) had confirmed malignant disease with bone metastases. The higher proportion of osteoblastic findings on scintigraphy compared to osteolytic findings suggests that the disease progression pattern in this cohort predominantly involved increased bone formation. The Chi-square analysis indicates significant associations between bone pain, CT bone metastases, bone scintigraphy findings, and the final malignant diagnosis. The results reveal that bone pain and CT-detected bone metastases have a highly significant correlation ($p < 0.001$), suggesting that clinical symptoms strongly align with imaging-confirmed metastatic involvement. Similarly, osteoblastic changes on bone scintigraphy and the final diagnosis of malignancy also show statistically significant associations ($p < 0.005$), supporting the reliability of these imaging findings in detecting malignant progression.

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Osteolytic changes exhibit a moderate significance ($p = 0.032$), indicating a weaker but still relevant relationship with metastatic bone disease. These findings reinforce the role of multimodal imaging in conjunction with clinical symptoms for the accurate detection and diagnosis of bone metastases in breast cancer patients.

Table 1 Age Group Distribution of Breast Cancer Patients

	Frequency	**Percent**
Age group 30-45	58	36.7
Age group 45-60	80	50.6
Age group above 60	20	12.7
Total	158	100.0

Table 2 Computed Tomography (CT) Findings of Breast Lesions in Left and Right Breast

CT appearance Left breast L/B	**Normal side**	**58**	**36.7**	**158**
	Hypodense cystic lesion	20	13.3	
	Heterogeneous cystic lesion	21	12.7	158
	Irregular hypodense lesion	14	8.9	158
	heterogeneous lobulated mass	26	16.5	158
	Heterogeneous Soft tissue mass	13	8.2	158
	Radical Mastectomy	6	3.8	158
CT appearance Right breast R/B	Normal	84	53.2	158
	Hypodense cystic lesion	12	7.6	
	Heterogeneous cystic lesion	5	3.2	158
	Irregular hypodense lesion	17	10.8	158
	heterogeneous lobulated mass	31	19.6	158
	Heterogeneous Soft tissue mass	8	5.1	158

CT appearance Left breast L/B	**Normal side**	**58**	**36.7**	**158**
	Radical Mastectomy	1	0.6	158

Table 3 Frequency of Clinical Breast Symptoms Among Participants

	Yes	**NO**	**Total participants**
Breast skin thickening	108 (68.4%)	50(31.8%)	158
Nipple discharge blood	53(33.5%)	105(66.5%)	158
Nipple discharge fluid	76 (48.1%)	82(51.9%)	158

Table 4 Bone Metastases Detection on Computed Tomography (CT) and Bone Scintigraphy (BS)

Bone metas CT findings	**Yes**	**59**	**37.3**	**158**
	No	99	62.7	158
BS osteoblastic	Yes	92	58.2	158
	No	66	41.8	158
BS osteolytic	Yes	69	43.7	158
	No	89	56.3	158
Bone metas findings	Yes	66	41.8	158
	No	92	58.2	158

Table 5 Final Diagnosis Distribution of Breast Cancer Patients

	Frequency	**Percent**
Benign	92	58.2
Malignant	66	41.8
Total	158	100.0

Table 6 Chi-square Analysis Results

	Chi-square	**p-value**
Bone Pain	19.253	0
CT Bone Metastases	19.253	0
BS Osteoblastic	7.911	0.005
BS Osteolytic	4.57	0.033
Final Diagnosis Malignant	7.911	0.005

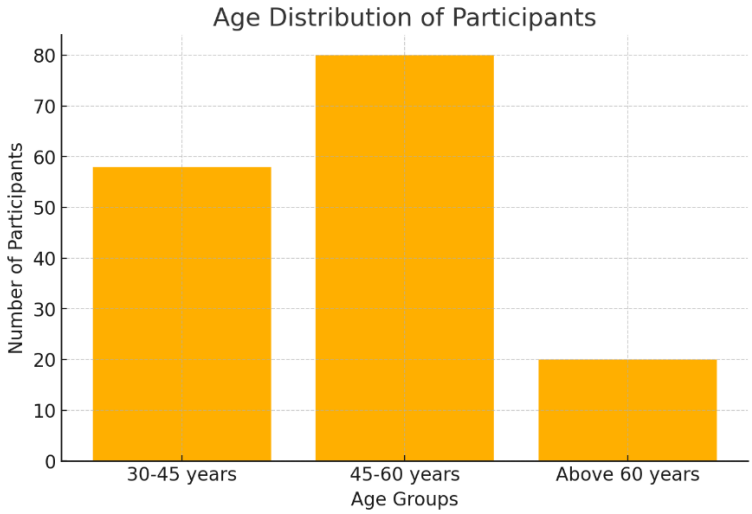

Figure 2 Age Distribution of Participants

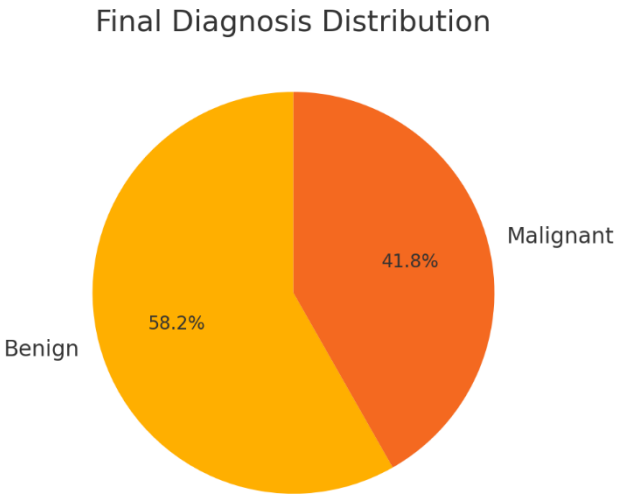

Figure 1 Final Diagnosis Distribution

DISCUSSION

The age distribution in this study revealed that the majority of breast cancer cases (50.6%) occurred in women aged 45–60 years, aligning with previous research that identified peak incidence within this range. A substantial proportion of patients presented with advanced-stage disease, particularly among those younger than 50 years, highlighting the persistent challenge of late-stage diagnosis (12). The findings underscore the necessity for early detection strategies, particularly in middle-aged women who constitute the highest-risk group. Bone involvement was observed in 62.7% of participants, corroborating prior studies that identified the skeleton as the most frequent site of metastasis in breast cancer (13). The high prevalence of bone metastases emphasizes the clinical burden of metastatic breast cancer and the associated complications, including pain, fractures, and impaired mobility. Various systemic symptoms, including fatigue, depression, and insomnia, frequently accompany bone metastases, further deteriorating the quality of life in affected individuals (14).

Computed tomography findings demonstrated diverse breast lesion characteristics, with a notable predominance of heterogeneous lobulated masses and irregular hypodense lesions (15). These imaging features are critical for distinguishing malignant from benign lesions and guiding clinical management. A significant observation in this study was the higher frequency of lesions in the left breast compared to the right, suggesting potential anatomical or physiological predispositions that warrant further investigation (16). CT also provided detailed visualization of bone metastases, aligning with previous literature reporting its high specificity in detecting structural bone alterations. However, the study findings indicated a predominance of degenerative and arthritic changes rather than widespread metastatic involvement, suggesting that additional imaging modalities might be necessary for comprehensive assessment (17). Bone scintigraphy findings revealed osteoblastic changes in 58.2% of participants and osteolytic changes in 43.7%, consistent with the well-documented mixed nature of bone metastases in breast cancer (18). The detection of osteoblastic lesions suggests a tendency toward increased bone formation in metastatic disease, which is particularly relevant for treatment planning. Additionally, abnormal tracer uptake was detected in 41.8% of participants, reinforcing the utility of bone scintigraphy in identifying early metastatic involvement (19). While bone scintigraphy remains a valuable tool for whole-body assessment, its limitations in detecting early intertrabecular metastatic patterns highlight the need for adjunctive imaging techniques, such as positron emission tomography-computed tomography (PET-CT) or magnetic resonance imaging (MRI), to enhance diagnostic accuracy (20).

This study's strengths include a well-defined participant cohort, standardized imaging protocols, and a comparative evaluation of CT and bone scintigraphy in diagnosing bone metastases. However, certain limitations must be acknowledged. The reliance on imaging findings without histopathological confirmation in all cases may have affected the specificity of the results. Additionally, the use of a single-center design and purposive sampling may limit the generalizability of the findings. Future research should incorporate larger,

multicenter cohorts and advanced imaging modalities to refine diagnostic accuracy further and explore potential correlations between imaging findings and molecular subtypes of breast cancer. The findings of this study reinforce the critical role of multimodal imaging in the evaluation of breast cancer bone metastases. The observed correlations between clinical symptoms, CT features, and scintigraphy findings highlight the necessity of an integrated diagnostic approach. Optimizing early detection strategies, refining imaging techniques, and developing targeted treatment protocols remain essential to improving outcomes for breast cancer patients with skeletal metastases.

CONCLUSION

The findings of this study highlight the diagnostic value of bone scintigraphy in detecting bone metastases in breast cancer patients, demonstrating its superiority over computed tomography in identifying metastatic involvement. Bone scintigraphy proved to be a more effective modality for early detection, making it a valuable tool in clinical practice, particularly for comprehensive skeletal assessment. While CT remains instrumental in providing detailed anatomical visualization, bone scintigraphy offers greater sensitivity in detecting metastatic lesions, reinforcing its role in guiding timely diagnosis and management. These results emphasize the importance of incorporating multimodal imaging approaches to enhance the accuracy of metastatic detection and improve patient outcomes.

Author Contribution

Author	Contribution
Muhammad Jahanzaib*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Nemal Tariq	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Aneela Ijaz	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Nadia Shahzadi	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Amina Ashfaq	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Javeria Batool	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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