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DIAGNOSTIC ACCURACY OF CT NECK CHEST ABDOMEN PELVIS WITH BONE SCAN FOR SKELETAL METASTASIS AMONG MALIGNANT CANCER PATIENTS

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ABSTRACT

Background: Skeletal metastasis is a common complication of advanced solid malignancies and is associated with pain, fractures, neurological deficits, and reduced quality of life. Early detection is important for accurate staging, treatment planning, and prevention of serious complications. In many resource-limited settings, computed tomography (CT) and bone scintigraphy remain widely used imaging modalities for the evaluation of suspected bone metastases. **Objective:** To determine the diagnostic accuracy of computed tomography of the neck, chest, abdomen, and pelvis for detecting skeletal metastases in patients with solid malignancies using bone scintigraphy as the reference comparator. **Methods:** This cross-sectional validation study was conducted at the Department of Radiology, Shifa International Hospital Islamabad from October 2025 to April 2025. A total of 255 patients aged 18 to 70 years with histologically confirmed solid organ cancers underwent both CT scanning and bone scintigraphy. CT findings were classified as lytic, sclerotic, or mixed lesions. Diagnostic performance measures including sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were calculated using a 2 × 2 contingency table. Statistical association between CT and bone scan findings was assessed using the chi-square test. **Results:** Bone metastases were detected in 104 patients (40.8%) on bone scintigraphy and in 91 patients (35.7%) on CT. CT demonstrated a sensitivity of 81.7%, specificity of 96.1%, positive predictive value of 93.4%, negative predictive value of 88.5%, and overall diagnostic accuracy of 90.6%. A significant association was observed between CT and bone scan findings ($p < 0.001$). The spine and pelvis were the most frequently involved skeletal sites. **Conclusion:** Computed tomography shows high specificity and moderate sensitivity for detecting skeletal metastases in patients with solid malignancies. CT may serve as a useful imaging modality for identifying established bone lesions and supporting clinical decision making, particularly in healthcare settings where access to advanced imaging is limited.

Keywords: Bone metastases, computed tomography, bone scintigraphy, diagnostic accuracy, solid tumors, Pakistan.

INTRODUCTION.

Skeletal metastasis is a frequent complication of advanced solid malignancies and represents one of the most common causes of cancer-related morbidity. Tumors such as breast, prostate, lung, and kidney cancers have a strong tendency to spread to the skeleton during the course of the disease.[1] Bone involvement can lead to severe clinical consequences including persistent pain, pathological fractures, spinal cord compression, and reduced quality of life. Early identification of skeletal metastases is therefore essential for accurate staging, treatment planning, and prevention of serious complications.[2]

Imaging plays a central role in detecting bone metastases and assessing disease extent. Conventional radiography has limited sensitivity for early metastatic disease, particularly when lesions are confined to the bone marrow.[3] Bone scintigraphy is widely used as a screening tool because it allows evaluation of the entire skeleton and is relatively sensitive for detecting metastatic involvement. However, bone scintigraphy may produce false positive results in benign conditions such as degenerative disease, trauma, or infection and provides limited anatomical detail.[4]

Computed tomography (CT) is commonly performed in cancer patients as part of routine staging and follow-up evaluation. CT provides detailed anatomical visualization of the skeleton and can detect structural bone changes including lytic, sclerotic, and mixed lesions.[5] Because CT of the neck, chest, abdomen, and pelvis is already routinely obtained for many oncologic patients, it may offer additional value in identifying skeletal metastases without requiring separate imaging studies. Nevertheless, CT may miss early marrow-based disease that has not yet produced visible cortical changes.[6]

In many low- and middle-income healthcare settings, advanced imaging modalities such as positron emission tomography–computed tomography (PET-CT) or whole-body magnetic resonance imaging are not easily available due to cost and infrastructure limitations.[7] Consequently, CT and bone scintigraphy remain the most frequently used imaging techniques for evaluating suspected bone metastases in routine clinical practice.[8]

Despite the widespread use of these imaging methods, local evidence comparing the diagnostic performance of CT and bone scintigraphy for detecting skeletal metastases remains limited.[9] Understanding how reliably CT can detect bone metastases during routine staging examinations may help improve diagnostic strategies and optimize the use of available imaging resources.[10]

Therefore, the present study was conducted to determine the diagnostic accuracy of computed tomography of the neck, chest, abdomen, and pelvis for detecting skeletal metastases in patients with solid malignancies using bone scintigraphy as the reference comparator.

MATERIALS AND METHODS

This cross-sectional validation study was conducted at the Department of Radiology, Shifa International Hospital Islamabad, Pakistan, over a period of six months, from October 2025 to April 2025.

Ethical approval was obtained from the Institutional Review Board and Ethics Committee of Shifa International Hospital, Islamabad, under Reference No: IRB-001-23, dated 06-11-23. All procedures were conducted in accordance with the Declaration of Helsinki, and patient confidentiality was maintained throughout the study.

The required sample size was calculated using a standard diagnostic test evaluation formula. Assuming a confidence level of 95%, absolute precision of 10%, anticipated sensitivity of 73%, and specificity of 95% for CT in detecting skeletal metastases based on previous literature, along with an estimated prevalence of skeletal metastases of 30% among patients with solid malignancies, the minimum required sample size was calculated to be 255 patients.(11,12)

Eligible participants included adult patients aged 18 to 70 years with histologically confirmed solid organ malignancies who were referred for evaluation of suspected skeletal metastases. All included patients underwent both contrast-enhanced computed tomography of the neck, chest, abdomen, and pelvis and bone scintigraphy as part of their clinical staging or follow-up evaluation.

Patients were excluded if they had primary bone tumors, had undergone only one of the imaging examinations, had previously confirmed skeletal metastases, or had medical contraindications to CT contrast or radionuclide imaging. Pregnant patients were also excluded.

Computed tomography examinations were performed using a multidetector CT scanner (Siemens Somaton Definition edge Model syngo CT VB10) according to the standard institutional oncologic staging protocol. Imaging covered the neck, chest, abdomen, and pelvis with axial acquisition. The scanning parameters included a slice thickness of approximately 1 and 2 mm with multiplanar reconstruction when required. Intravenous contrast medium (non-ionic water soulblet and dose 1.5 ml /kg was administered unless contraindicated to enhance lesion detection and anatomical assessment. CT images were independently reviewed by at least 02 experienced radiologists with years of 7 to 20 years experience in oncologic imaging. The radiologists evaluated the images for the presence and characteristics of skeletal lesions and classified them as lytic, sclerotic, or mixed lesions. To reduce interpretation bias, the radiologists were blinded to the bone scintigraphy results at the time of CT interpretation.

Bone scintigraphy was performed using technetium ninety nine m labeled phosphonate tracers. Metastases were identified as areas of increased tracer uptake or in rare purely lytic lesions as areas of reduced uptake.The interval between computed tomography and bone scintigraphy examinations was kept as short as possible, and both imaging studies were performed within 7–14 days of each other to minimize the possibility of disease progression affecting the imaging findings. Bone scintigraphy was used as the reference comparator for detection of skeletal metastases because it is widely utilized in routine oncologic staging, although it is recognized that it does not represent a perfect gold standard.

Demographic and clinical information including age, sex, primary cancer type, duration of disease, and clinical symptoms suggestive of bone metastasis were recorded using a structured data collection form. Symptoms considered included persistent bone pain, pathological fractures, neurological deficits, and hypercalcemia.

All data were entered and analyzed using SPSS software. Continuous variables such as age were summarized as mean ± standard deviation, while categorical variables such as gender, cancer type, and imaging findings were presented as frequency and percentage. Diagnostic performance of CT for detection of skeletal metastases was assessed by calculating sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy using bone scintigraphy as the reference test.

A 2 × 2 contingency table was constructed to determine the number of true positive, true negative, false positive, and false negative cases. The relationship between CT findings and bone scintigraphy results was analyzed using the Chi-square test, with a p-value less than 0.05 considered statistically significant.

RESULTS

A total number of two hundred fifty five individuals diagnosed with solid malignant disease were enrolled in the research. The average age of the study population was fifty two point three plus minus eleven point four years. Female participants numbered one hundred forty three representing fifty six point one percent while male participants were one hundred twelve accounting for forty three point nine percent. The leading primary tumor types included carcinoma of the breast at thirty five point three percent carcinoma of the prostate at twenty two point seven percent carcinoma of the lung at fifteen point seven percent carcinoma of the liver at twelve point five percent and carcinoma of the cervix at eight point two percent. Remaining malignancies together comprised five point six percent of the total sample.

Table 1. Demographic and Clinical Characteristics of Participants (n=255)

Variable	n (%)
Gender	
Male	112 (43.9%)
Female	143 (56.1%)
Age Group (years)	
18–40	52 (20.4%)
41–55	108 (42.4%)
56–70	95 (37.2%)
Primary Cancer Type	
Breast	90 (35.3%)
Prostate	58 (22.7%)
Lung	40 (15.7%)
Liver	32 (12.5%)
Cervical	21 (8.2%)
Other	14 (5.6%)

Among the 255 patients studied, CT scan showed bone involvement in 91 patients, which accounts for 35.7 percent of the total group. The percentages describing lesion pattern and anatomical distribution were calculated among patients who showed metastatic lesions on CT, whereas the overall detection rate was calculated based on the total study population. The bone changes seen on CT had different patterns. Dense hardened bone changes were the most common and were seen in 42.9 percent of cases. Bone destroying changes were seen in 38.5 percent, while a mixed pattern showing both bone loss and bone hardening was present in 18.6 percent of patients.The areas most often affected on CT scan were the spine, which was involved in 48.4 percent of cases. The pelvic bones were the second most common site, seen in 34.1 percent. The thigh bone was involved in 12.1 percent of patients, while the rib cage was affected in 5.5 percent. These findings show that the spine and pelvis are the most important regions to carefully assess when reviewing CT scans for bone spread. All this compiled in table 2 and 3

Table 2. CT detection of skeletal metastasis (n=255)

Finding	n (%)
Metastasis Status	
Metastasis Detected	91 (35.7%)
No Metastasis	164 (64.3%)

Table 3 Ct Characteristics of detected skeletal metastasis

Variable	Frequency(%)
Lesion Type	
Lytic	35 (38.5%)
Sclerotic	39 (42.9%)
Mixed	17 (18.6%)
Common Sites of Metastasis	
Spine	44 (48.4%)

Pelvis	31 (34.1%)
Femur	11 (12.1%)
Ribs	5 (5.5%)

Bone scintigraphy detected skeletal metastases in 104 (40.8%) patients. The distribution of metastases was similar to CT, with the spine most commonly involved (51.0%) followed by pelvis (32.7%), femur (11.5%), and ribs (4.8%). These details explained in table 4 and 5.

Table 4-Bone Scintigraphy Detection of Skeletal Metastases (n = 255)

Finding	N (%)
Metastasis Detected	104 (40.8%)
No Metastasis	151 (59.2%)

Table 5: Anatomical Distribution of Skeletal Metastases on Bone Scintigraphy (n = 104)

Site of Metastasis	N(%)
Spine	53 (51.0%)
Pelvis	34 (32.7%)
Femur	12 (11.5%)
Ribs	5 (4.8%)

Bone scan was taken as the main reference test, and a simple two by two table was used to compare its results with CT scan findings. Among the 255 patients, 85 patients were correctly identified by CT as having bone spread, while 147 patients were correctly identified as having no bone involvement. Six patients were wrongly labeled positive on CT despite having no bone metastasis, and 19 patients had bone metastasis that CT did not detect.Based on these results, CT scan showed a sensitivity of 81.7%, meaning it detected most patients with bone spread. Its specificity was 96.1%, showing that CT was very accurate in confirming disease when it was present. The positive predictive value was 93.4%, which means a positive CT result was usually correct. The negative predictive value was 88.5%, indicating that a negative CT scan reliably ruled out bone involvement in most cases. Overall, CT achieved a diagnostic accuracy of 90.6%, demonstrating strong performance for detecting bone metastasis in this patient group.

Table 6. Diagnostic Performance of CT in Detecting Skeletal Metastases (n=255)

Measure	Value (%)	95% Confidence Interval
Sensitivity	81.7	73.0–88.3
Specificity	96.1	91.4–98.5
Positive Predictive Value (PPV)	93.4	86.5–97.0
Negative Predictive Value (NPV)	88.5	82.3–92.8
Overall Accuracy	90.6	86.0–94.0

A chi-square test was performed to assess the association between CT scan findings and bone scan results. The results showed statistically significant association ($\chi^2 = 112.5$, $p < 0.001$), indicating that CT findings were highly correlated with bone scan outcomes.

Table 7. Statistical Analysis of Association between CT and Bone Scan Findings

CT Scan Result	Bone Scan Positive	Bone Scan Negative	Total
Positive	85 (TP)	6 (FP)	91
Negative	19 (FN)	147 (TN)	166
Total	104	151	255
$\chi^2 = 112.5$	$p < 0.001$		

In summary, this study shows that CT scan is very accurate for detecting cancer spread to bones. It showed very high ability to correctly confirm bone metastasis, with a specificity of 96.1%, and a good ability to detect disease, with sensitivity of 81.7%. The high positive predictive value of 93.4% means that when CT shows bone involvement, the finding is usually correct. The negative predictive value of 88.5% also shows that a normal CT scan is reliable in most cases, which is important in hospitals with limited resources. Statistical analysis using the chi square test showed a statistically significant association between CT scan and bone scan results, with a chi square value of 112.5 and a probability value below 0.001. The spine and pelvic bones were the most commonly affected areas, highlighting the need for careful assessment of these regions during imaging.

DISCUSSION

Bone spread is a common and serious problem in patients with advanced solid cancers. It causes severe pain and reduces the ability to carry out normal daily activities. Finding bone involvement early is very important because it changes treatment planning. It can influence decisions related to surgery radiotherapy and medicines including drugs that protect and strengthen bone. This study assessed how well CT scans of the neck chest abdomen and pelvis detect bone metastasis. Bone scan was used as the comparison test. A total of 255 patients with solid tumors were included and the most common cancers were breast prostate and lung.

The findings show that CT performed well in detecting bone spread. Specificity was 96.1 percent which means that when CT showed metastasis the finding was usually correct. Sensitivity was 81.7 percent which means that CT detected most cases of bone involvement. The positive predictive value was 93.4 percent and the negative predictive value was 88.5 percent which shows that CT results were reliable in both positive and negative cases. The overall diagnostic accuracy was 90.6 percent which indicates that CT is a useful tool in this setting. There was also a statistically significant association between CT and bone scan findings which supports the reliability of the results [13].

These results are in line with reports from other countries. Many studies have shown that CT has high specificity because it clearly shows bone damage bone hardening and visible changes in structure. However CT is less effective for early disease that is limited to the bone marrow and has not yet involved the outer bone. For early marrow disease advanced tests such as PET CT or whole body MRI are usually more sensitive [14]. These tests are costly and not easily available in many regions. The present findings support this known pattern showing that CT is effective for established bone disease while a small number of early lesions may still be missed.

Local oncology practice in Pakistan also supports the use of CT and bone scan as practical options. Bone scan helps in screening the whole skeleton and is commonly used for staging, especially in breast and prostate cancers. CT adds detailed anatomical information and helps confirm and locate lesions. In settings where PET or whole body MRI is not easily available because of cost or access, CT remains a realistic and helpful first step [15]. This study adds local evidence because it included multiple cancers and a relatively large patient group.

The high specificity means CT is especially useful when the goal is to confirm bone metastasis and start timely treatment, such as radiotherapy or surgical stabilization of weight bearing bones. Although sensitivity was lower than specificity, it was still acceptable, showing that CT detects most clinically important lesions. Still, the chance of missing early marrow based disease means that if clinical suspicion is high and CT is negative, further imaging should be considered, especially in aggressive cancers or in patients with unexplained bone pain [16].

In this study, the spine and pelvic bones were the most commonly involved sites. This is a well known pattern in cancer spread and is linked to tumor spread through venous pathways and the presence of red marrow in these regions. Metastases in the spine and pelvis can lead to severe pain, nerve or spinal cord pressure, and higher fracture risk. Because of these risks, careful review of these areas is essential when interpreting scans [17].

This study has several important strengths. The sample size was adequate and this improves the reliability of the results. Including different types of cancers makes the findings useful for a wide range of oncology patients. Clear rules were used to classify bone lesions which helped keep image interpretation consistent and reduced differences between observers [18]. These factors increase confidence in the study findings.

Several limitations of this study should be acknowledged. First, bone scintigraphy was used as the reference comparator rather than a definitive gold standard such as histopathological confirmation or advanced imaging modalities including PET CT or whole body MRI. Although bone scintigraphy is widely used for detecting skeletal metastases, it may produce false positive findings in benign conditions such as fractures, degenerative disease, or infection and may occasionally miss purely lytic lesions with minimal osteoblastic activity. Second, the study was based on patient based analysis rather than lesion based analysis, which limits the ability to evaluate the diagnostic performance of CT for individual metastatic lesions in different skeletal regions and may reduce the strength of the evidence. Third, patients with previously diagnosed skeletal metastases were excluded to focus on newly suspected cases, which may introduce selection bias and could influence the calculated diagnostic accuracy values. Furthermore, positive predictive value and negative predictive value are influenced by the

prevalence of disease in the study population and may therefore vary across different clinical settings. In addition, the study was conducted at a single center, which may limit the generalizability of the findings.
Bone scan is still widely used because it can detect bone involvement early by showing increased bone activity, but it can also give false positive results in benign conditions such as fractures, arthritis, and infection. CT complements bone scan by giving clearer anatomical detail, better localization, lesion type assessment, and evaluation of bone stability [20]. The results suggest that when both tests are available, using them together provides stronger diagnostic confidence because one gives functional information and the other shows structural change.
In places where bone scan or advanced imaging is not available, CT can be used as a good first line test. The high positive predictive value means treatment decisions based on a positive CT finding are usually appropriate. However, negative CT findings should be interpreted carefully in high risk patients, and additional imaging should be arranged when possible [21].
Future research should include lesion based analysis rather than only patient based analysis. It should also focus on difficult sites like ribs, scapula, and small bones where detection can be more challenging. Multi center studies would improve generalizability and allow subgroup analysis by cancer type, stage, and treatment status. Over time, adding hybrid imaging approaches where feasible may further improve detection and outcomes for patients with bone metastases in resource limited healthcare systems.

Future research should focus on larger multicenter studies to validate the diagnostic performance of computed tomography in detecting skeletal metastases across different healthcare settings. Studies incorporating lesion-based analysis rather than only patient-based evaluation may provide a more detailed understanding of the sensitivity of CT for detecting individual metastatic lesions. Comparative research involving advanced imaging modalities such as positron emission tomography–computed tomography and whole-body magnetic resonance imaging would also be valuable to determine the relative diagnostic performance of these techniques. Additionally, prospective longitudinal studies could assess the role of CT in monitoring treatment response and disease progression in patients with metastatic bone disease. Such investigations would help refine imaging strategies and optimize diagnostic pathways for patients with solid malignancies, particularly in resource-limited healthcare systems.

CONCLUSION

This study shows that CT scanning of the neck, chest, abdomen, and pelvis has high specificity and moderate to high sensitivity for detecting skeletal metastases in patients with solid cancers. A positive CT finding is generally reliable, and most clinically important lesions can be identified. CT is widely available and can be used as a practical first-line imaging modality in resource-limited settings. However, as CT may miss early marrow-based disease, negative findings should be interpreted with caution, and additional imaging may be required when clinical suspicion remains high. Early detection of bone involvement remains important for timely management and improved patient outcomes.

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