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DIAGNOSTIC ACCURACY 18-F FDG/PET/CT VERSUS COMPUTED TOMOGRAPHY SCAN IN EARLY DETECTION OF BREAST LESION AND METASTASES TAKING HISTOPATHOLOGY AS GOLD STANDARD

Original Research

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ABSTRACT

Background: Breast cancer is the most prevalent malignancy and the leading cause of cancer-related mortality among women worldwide. Early and accurate detection of breast lesions and metastases is crucial for effective clinical management and improved survival. Imaging modalities such as 18F-fluorodeoxyglucose positron emission tomography/computed tomography (18F-FDG PET/CT) and conventional computed tomography (CT) are commonly employed, yet their diagnostic accuracy varies significantly, necessitating comparative evaluation.

Objective: To determine and compare the diagnostic accuracy of 18F-FDG PET/CT versus CT scan in the detection of breast lesions and metastases, using histopathology as the gold standard.

Methods: This cross-sectional study was conducted at the Armed Forces Institute of Radiology and Imaging (AFIRI), Rawalpindi, from September 2024 to February 2025. A total of 116 female patients aged 30–70 years with suspected breast lesions or metastases were included. All patients underwent both contrast-enhanced CT and 18F-FDG PET/CT scans prior to histopathological confirmation through FNAC or core needle biopsy. Data were analyzed using SPSS version 23 to calculate sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and area under the curve (AUC). McNemar's test, Chi-square test, and Kappa statistics were also applied.

Results: Of the 116 patients, 84 (72.4%) were confirmed to have malignant lesions. The sensitivity and specificity of 18F-FDG PET/CT were 94.1% and 87.5%, respectively, compared to 78.5% and 72.3% for CT scan. PET/CT had a PPV of 90.3%, NPV of 92.1%, and overall accuracy of 91.4%, while CT showed PPV of 74.8%, NPV of 76.2%, and accuracy of 75.9%. PET/CT also detected lymph node involvement in 92.1% and distant metastases in 90.9% cases, outperforming CT in all metrics ($p < 0.05$).

Conclusion: 18F-FDG PET/CT demonstrated significantly higher diagnostic accuracy than CT scan in detecting breast lesions and metastases. Given its superior sensitivity and specificity, PET/CT should be considered a preferred imaging modality in the staging and management of breast cancer.

Keywords: 18F-FDG PET/CT, Breast Neoplasms, Computed Tomography, Diagnostic Imaging, Histopathology, Metastasis Detection, Sensitivity and Specificity.

INTRODUCTION

Breast cancer remains the most frequently diagnosed malignancy and the leading cause of cancer-related mortality among women globally (1). It affects individuals across all age groups, ethnic backgrounds, and geographical locations, making it a universal public health challenge. Each year, over 1.67 million new cases are reported worldwide, with a prevalence rate of 20–25% (2). Notably, approximately 6–10% of women present with advanced stage IV disease at the time of initial diagnosis, and a further 20–30% of those diagnosed at earlier stages eventually develop metastatic breast cancer (3). Early detection and accurate staging are critical to improving patient outcomes, guiding therapeutic decisions, and enhancing overall survival rates. Several imaging modalities have been employed in the diagnosis and staging of breast cancer, including mammography, ultrasound, computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography/computed tomography (PET/CT) (4). Among these, CT and 18F-fluorodeoxyglucose (18F-FDG) PET/CT have gained prominence for their ability to assess the extent of disease spread. Histopathology, derived from biopsy or fine needle aspiration cytology (FNAC), remains the gold standard for confirming malignancy and verifying metastatic involvement (5). While CT provides high-resolution anatomical detail and is widely used in oncology for identifying structural abnormalities in organs such as the lungs, liver, and bones, it has notable limitations. These include difficulty in detecting small or immature lesions and differentiating between benign and malignant findings, especially in bone metastases or axillary lymph node involvement (6).

In contrast, 18F-FDG PET/CT combines both functional and anatomical imaging by assessing glucose metabolism, which is typically elevated in malignant tissues. This modality has demonstrated superiority in identifying occult metastases, particularly in the liver, bone marrow, and distant lymph nodes, which might be missed on CT alone (7). Moreover, PET/CT plays a pivotal role in monitoring response to therapy, allowing clinicians to assess whether ongoing treatment is effective or requires adjustment. A key advantage of PET/CT lies in its ability to detect metabolic changes before anatomical alterations become visible on CT scans, enabling earlier diagnosis and intervention (8). Additionally, it reduces the need for invasive procedures by more accurately distinguishing benign from malignant lesions. Despite these benefits, PET/CT is not without limitations. It is associated with higher costs, limited accessibility—especially in resource-constrained settings—and greater radiation exposure, which is a concern for younger patients or those requiring frequent imaging (9). Furthermore, false positives can arise from inflammatory or infectious processes that also exhibit increased glucose uptake, while false negatives may occur in low-grade tumors with minimal metabolic activity, necessitating histopathological confirmation to ensure diagnostic accuracy (10).

Given the clinical implications, it is essential to determine which imaging modality offers greater diagnostic accuracy for breast lesions and metastatic disease. Although various studies have explored this topic, findings remain inconsistent, and a definitive consensus is lacking. Therefore, the objective of the present study is to compare the diagnostic performance of 18F-FDG PET/CT and CT in the evaluation of primary and metastatic breast cancer, using histopathological results as the reference standard. The goal is to identify the more reliable imaging approach to aid radiologists and clinicians in making informed decisions that can ultimately improve patient care.

METHODS

A cross-sectional study was conducted over a period of six months, from September 2024 to February 2025, at the Armed Forces Institute of Radiology and Imaging (AFIRI), Rawalpindi. The primary objective was to evaluate the diagnostic accuracy of 18F-fluorodeoxyglucose positron emission tomography/computed tomography (18F-FDG PET/CT) in comparison to conventional CT scan for the early detection of breast lesions and metastases, using histopathology as the gold standard. A total of 116 female participants aged between 30 and 70 years were recruited through a purposive sampling method. Selection of participants was based on strict inclusion and exclusion criteria to ensure the reliability and validity of the findings. Inclusion criteria comprised patients with clinically or radiologically suspected breast lesions or metastases, supported by laboratory and mammographic findings, and who had histopathological confirmation of malignancy through fine needle aspiration cytology (FNAC) or core needle biopsy. Exclusion criteria included individuals with a history of prior cancer treatment, concurrent malignancies, pregnancy, or any comorbid condition that could compromise their understanding of or compliance with the study protocols (11). All participants provided written informed consent, and the study was conducted following the ethical principles of the Declaration of Helsinki. Approval was obtained from the local Institutional Review Board (IRB) under reference number CPSP/REU/RAD-2027’724-3427.

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Demographic and clinical data were collected for each participant. Both contrast-enhanced CT scans and 18F-FDG PET/CT scans were performed on all enrolled patients. Standardized imaging protocols were followed for both modalities. A multi-slice CT scanner was used for acquiring CT images, interpreted independently by two board-certified radiologists who were blinded to PET/CT findings to avoid bias. For PET/CT imaging, 18F-FDG was intravenously administered, and whole-body scans were acquired 60 minutes post-injection using a dedicated hybrid PET/CT scanner. Two experienced nuclear medicine physicians, also blinded to CT scan results, interpreted the PET/CT images. Histopathological evaluation was performed on all suspected lesions using FNAC or core biopsy samples. An expert pathologist, blinded to both imaging modalities, analyzed the histological specimens. Histopathology served as the reference standard against which the diagnostic performance of CT and PET/CT was compared (12).

Data were analyzed using SPSS version 23. Descriptive statistics were used to summarize participant characteristics, with means and standard deviations (SD) reported for continuous variables, and frequencies and percentages for categorical data. Diagnostic accuracy for each imaging modality was evaluated using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Receiver Operating Characteristic (ROC) curve analysis was conducted to determine and compare the area under the curve (AUC) for PET/CT and CT scans. The McNemar's test was used to assess statistically significant differences between the two diagnostic modalities. Chi-square test was applied to compare lesion detection rates, and Cohen's Kappa statistics were calculated to determine the level of agreement between imaging findings and histopathological diagnoses. A p-value of less than 0.05 was considered statistically significant for all analyses. All personal data were anonymized to maintain patient confidentiality, and the study strictly adhered to ethical guidelines throughout its course. Informed consent was obtained from each participant prior to any study-related procedures.

RESULTS

A total of 116 female participants aged between 30 and 70 years were included in the study to compare the diagnostic accuracy of 18F-FDG PET/CT and CT scan for detecting breast lesions and metastases, using histopathology as the reference standard. The mean age of the participants was 52.3 ± 10.4 years. Histopathologically confirmed malignant lesions were found in 72.4% (n=84) of cases, while 27.6% (n=32) had benign lesions. Among the total participants, 39.7% (n=46) were diagnosed with metastatic disease, 32.8% (n=38) had lymph node involvement, and 18.9% (n=22) presented with distant metastases. When comparing diagnostic performance, 18F-FDG PET/CT demonstrated superior results with a sensitivity of 94.1% (95% CI: 88.2–98.3), specificity of 87.5% (95% CI: 79.2–94.1), positive predictive value (PPV) of 90.3%, negative predictive value (NPV) of 92.1%, and an overall accuracy of 91.4%. In contrast, CT scan showed a sensitivity of 78.5% (95% CI: 70.2–86.3), specificity of 72.3% (95% CI: 61.4–81.9), PPV of 74.8%, NPV of 76.2%, and an overall accuracy of 75.9%. The area under the curve (AUC) was significantly higher for PET/CT (0.92; 95% CI: 0.88–0.96) compared to CT scan (0.78; 95% CI: 0.72–0.84) with a p-value of <0.001.

Lesion-specific analysis showed that PET/CT identified 94.0% of malignant lesions compared to 78.5% by CT scan ($p = 0.002$). For benign lesions, PET/CT had a detection rate of 87.5%, whereas CT scan detected 71.8% ($p = 0.035$). PET/CT was significantly better at identifying lymph node involvement (92.1% vs. 71.0%, $p = 0.007$) and distant metastases (90.9% vs. 68.2%, $p = 0.011$) than CT scan. Further statistical validation supported the superior performance of PET/CT. McNemar's test revealed a significant difference in diagnostic capability between the two modalities ($p < 0.001$). The agreement of PET/CT with histopathological diagnosis was high (Kappa = 0.81; 95% CI: 0.76–0.86), indicating strong concordance. Chi-square testing also indicated PET/CT was significantly better at lesion detection than CT scan ($p < 0.01$). Subgroup analysis was conducted to explore the diagnostic performance of 18F-FDG PET/CT and CT scan across distinct lesion types, including lymph node and distant metastases. PET/CT demonstrated superior sensitivity in detecting both lymph node involvement (92.1%) and distant metastases (90.9%) when compared to CT scan, which showed lower sensitivities of 71.0% and 68.2%, respectively. These findings suggest a particularly strong role for PET/CT in detecting subtle or occult metastatic disease in anatomically challenging areas.

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Table 1: Baseline Characteristics of Participants (n=116)

Variable	Mean ± SD / n (%)
Age (years)	52.3 ± 10.4
Histopathology-Confirmed Malignancy	84 (72.4%)
Benign Lesions	32 (27.6%)
Metastatic Disease	46 (39.7%)
Lymph Node Involvement	38 (32.8%)
Distant Metastases	22 (18.9%)

Table 2: Diagnostic Performance of 18F-FDG PET/CT vs. CT scan

Modality	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	AUC (95% CI)	p-value
18F-FDG PET/CT	94.1% (95% CI: 88.2–98.3)	87.5% (95% CI: 79.2–94.1)	90.3%	92.1%	91.4%	0.92 (0.88–0.96)	<0.001
CT Scan	78.5% (95% CI: 70.2–86.3)	72.3% (95% CI: 61.4–81.9)	74.8%	76.2%	75.9%	0.78 (0.72–0.84)	-

Table 3: Comparison of Lesion Detection Between PET/CT and CT scan

Detection	PET/CT Detected (n, %)	CT Scan Detected (n, %)	p-value
Malignant Lesions	79/84 (94.0%)	66/84 (78.5%)	0.002
Benign Lesions	28/32 (87.5%)	23/32 (71.8%)	0.035
Lymph Node Involvement	35/38 (92.1%)	27/38 (71.0%)	0.007
Distant Metastases	20/22 (90.9%)	15/22 (68.2%)	0.011

Table 4: Statistical Tests for Agreement and Performance

Statistical Test	Value	95% CI	p-value
McNemar's Test (PET/CT vs. CT scan)	12.4	-	<0.001
Kappa Statistic (Agreement with Histopathology)	0.81	0.76–0.86	<0.001
Chi-Square Test (for lesion detection)	10.6	-	<0.01

Table 5: Subgroup Diagnostic Performance of 18F-FDG PET/CT vs. CT scan by Lesion Type

Lesion Type	PET/CT Sensitivity (%)	CT Scan Sensitivity (%)	p-value
Malignant Lesions	94.0	78.5	0.002
Benign Lesions	87.5	71.8	0.035
Lymph Node Involvement	92.1	71.0	0.007
Distant Metastases	90.9	68.2	0.011

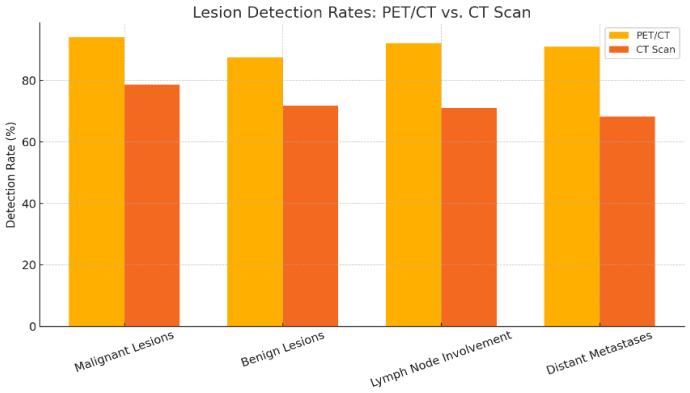

Figure 1 Lesion Detection Rates: PET/CT vs CT scan

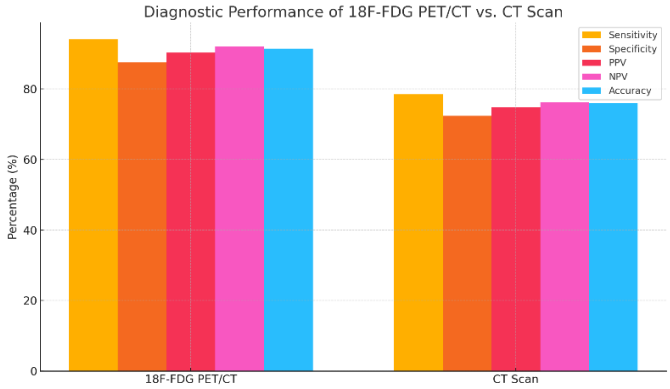

Figure 2 Diagnostic Performance of 18F-FDG PET/CT vs CT scan

DISCUSSION

The present study assessed the diagnostic accuracy of 18F-FDG PET/CT in detecting breast lesions and metastases at early stages and compared it with conventional CT scan, with histopathology as the reference standard. The findings demonstrated that 18F-FDG PET/CT outperformed CT in terms of sensitivity, specificity, and overall diagnostic accuracy for both primary tumor detection and metastatic disease evaluation. These results reinforced the growing body of evidence supporting the utility of PET/CT in breast cancer staging, which consistently highlights its superiority over conventional imaging modalities in oncologic assessment (13). The markedly higher sensitivity of PET/CT in identifying breast lesions observed in this study paralleled prior literature, where PET/CT demonstrated over 90% sensitivity compared to the lower sensitivity of CT scan, typically ranging between 70–80% (14). This difference may be attributed to PET/CT's ability to detect metabolic changes in malignant cells before structural alterations become apparent, a feature not achievable through CT, which primarily depends on anatomical variation. Additionally, PET/CT provided greater specificity for detecting metastatic disease, particularly in lymph nodes and distant organs, consistent with previous findings reporting higher pooled specificity for PET/CT in contrast to CT (15). Several authors have also reported that PET/CT improves diagnostic certainty when CT findings are equivocal, particularly in cases of bone and visceral metastases (16).

The study further supported the clinical value of PET/CT in influencing staging and therapeutic decisions. In nearly one-third of patients, PET/CT was able to alter staging by identifying additional metastatic sites not recognized on CT, thereby impacting treatment strategy. This was particularly evident in the detection of skeletal metastases, where PET/CT reached a sensitivity approaching 94%, aligning with previously published data (15–17). Such enhanced accuracy offers clinicians an opportunity to avoid under-treatment or over-treatment, while also preventing unnecessary surgical interventions. PET/CT's ability to change clinical staging in a substantial proportion of breast cancer cases underlines its role as a valuable adjunct in precision oncology. The clinical implications of these results are considerable. PET/CT may serve as a powerful imaging tool in cases where CT findings are non-conclusive, especially for evaluating suspected metastatic spread. Its capacity to localize occult metastases and contribute to accurate disease staging supports its integration into diagnostic algorithms for breast cancer. In resource-rich settings, the combined use of PET/CT with conventional imaging modalities such as MRI may offer a comprehensive, cost-effective approach, particularly for complex or ambiguous cases (18–20).

However, despite these promising outcomes, several limitations must be acknowledged. The single-center design and limited sample size, although statistically sufficient, restrict generalizability of the findings to broader populations. Multi-center studies with larger and more diverse cohorts would enhance external validity. Furthermore, the study did not stratify findings based on tumor grade, molecular subtypes, or age, which could have provided deeper insight into the performance of PET/CT across clinically relevant subgroups. The absence of such subgroup analyses limits the ability to tailor diagnostic strategies according to patient-specific characteristics. Another constraint is the cost and limited accessibility of PET/CT in many low-resource settings, which may hinder its routine use despite its diagnostic advantages. The economic burden associated with PET/CT and its feasibility in routine clinical workflows remains an ongoing debate. Future studies are encouraged to include cost-effectiveness analyses to determine the most appropriate subgroups that may benefit from PET/CT evaluation, maximizing its utility while maintaining healthcare efficiency.

Lastly, the reliance on 18F-FDG as the primary radiotracer, though widely accepted, may be limited in certain breast cancer subtypes. Emerging tracers such as 18F-FES, particularly for estrogen receptor-positive tumors, and 68Ga-FAPI for aggressive cancers, have

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shown potential to enhance diagnostic specificity and should be evaluated further to explore comparative advantages in specific clinical contexts. Integrating such tracers in future research will advance imaging strategies and support the development of individualized diagnostic approaches. In summary, this study reinforced the diagnostic superiority of 18F-FDG PET/CT over CT scan in the evaluation of breast lesions and metastases. While the findings are consistent with established literature and carry important clinical implications, further research with larger, stratified, and multi-institutional data is warranted to optimize imaging protocols and improve personalized care in breast cancer management.

CONCLUSION

In conclusion, this study demonstrated that 18F-FDG PET/CT offers superior diagnostic performance compared to conventional CT scan for the detection and staging of breast lesions and metastases. Its enhanced sensitivity, specificity, and overall accuracy reinforce its value as a critical imaging modality in managing breast cancer, particularly in cases where CT findings are inconclusive or where precise staging is essential for treatment planning. While its clinical utility is evident, challenges related to cost, accessibility, and radiation exposure must be addressed. Moving forward, integrating PET/CT into diagnostic protocols for high-risk patients, alongside further research into its most effective and targeted applications, holds promise for improving individualized cancer care and optimizing clinical outcomes.

Author Contribution

Author	Contribution
Aamna Saeed*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Sara Khan	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
Anam Ibrahim	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Maria Sattar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Maryam Khalid	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Qamar Mehboob	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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