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Original Research Article

Comparative Evaluation of PET/CT and Conventional Imaging (USG & CECT) for Assessing Clinically N0 Neck in Upper Aerodigestive Tract Squamous Cell Carcinoma

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Abstract:

Background: Accurate detection of occult cervical lymph node metastasis in clinically N0 neck remains a major challenge in upper aerodigestive tract squamous cell carcinoma (UADT SCC), significantly influencing prognosis and treatment decisions.

Aim: To compare the diagnostic performance of PET/CT with conventional imaging modalities (USG and CECT) in detecting occult nodal metastasis.

Methodology: This prospective observational study included 80 patients with histopathologically confirmed UADT SCC and clinically N0 neck. All patients underwent preoperative USG, CECT, and 18F-FDG PET/CT, followed by neck dissection. Histopathology served as the gold standard. Diagnostic parameters were calculated and compared.

Results: Occult metastasis was detected in 35% of patients. PET/CT demonstrated superior performance with sensitivity (89.3%), specificity (92.3%), and accuracy (91.3%), compared to CECT (75%, 84.6%, 81.3%) and USG (64.3%, 76.9%, 72.5%). PET/CT also showed the highest PPV (86.2%) and NPV (94.1%).

Conclusion: PET/CT is more accurate than USG and CECT in evaluating clinically N0 neck and may help reduce unnecessary interventions. However, it should be used as an adjunct within a multimodal diagnostic approach.

Keywords: PET/CT, USG, CECT, clinically N0 Neck, Squamous Cell Carcinoma, Occult Metastasis.

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Introduction

Head and neck squamous cell carcinoma (HNSCC) which primarily affects the upper aerodigestive tract constitutes a major worldwide health problem because of its high rates of occurrence and its resulting illnesses and deaths [1]. The presence or absence of cervical lymph node metastasis serves as the most important prognostic factor which affects treatment decisions and disease development and patient survival rates in these cancers. When cervical lymph nodes become involved with cancer doctors consider this development as one of the most essential prognostic indicators which decreases survival rates by almost 50 percent. The medical field still faces challenges in effectively identifying nodal metastasis for patients who show no signs of neck cancer with clinically negative neck (cN0) results despite progress in diagnostic and treatment methods.

The process of treating patients who have clinically N0 neck cancer and upper aerodigestive tract squamous cell carcinoma remains a topic of ongoing debate. The clinical examination fails to find both detectable lymphadenopathy and lymphadenopathy which can be seen through radiological imaging yet many of these patients have hidden metastatic disease. The research indicates that the occurrence of hidden cervical metastases through clinical examination ranges between 30 percent and 50 percent based on both the specific body region and the cancer stage of the primary tumor. The high likelihood of discovering concealed nodal disease has prompted medical professionals to implement elective neck treatments which include elective neck dissection and radiotherapy as standard procedures for patients who show no clinical signs of metastatic spread [2].

The main goal of elective treatment is to enhance regional control and survival rates, but the treatment comes with negative aspects. A considerable number of patients subjected to elective neck treatment are later found to have no metastatic involvement, thereby exposing them unnecessarily to surgical morbidity, radiation-related complications, psychological stress, and increased healthcare costs [3]. Patients experience major declines in their quality of life due to complications that include shoulder dysfunction and nerve injury and fibrosis and cosmetic deformities. The medical field requires a dependable method which can accurately detect hidden metastasis to allow proper patient classification and prevent unnecessary medical procedures.

The estimated risk of hidden metastasis which doctors use to determine treatment strategies for clinically N0 neck cases. The medical community accepts that elective neck treatment becomes necessary when patients present with a risk level above 15 to 20 percent. The estimation process remains challenging because tumors exhibit different biological characteristics and their location and patient-specific factors affect their behavior. The preoperative evaluation process of primary tumors and cervical lymph node conditions depends on the essential function which imaging technologies provide to medical professionals.

Radiologists use standard imaging methods which include ultrasonography (USG) and contrast-enhanced computed tomography (CECT) and magnetic resonance imaging (MRI) to assess cervical lymph nodes [5]. The imaging techniques show important body structure information and they can identify lymph node growth and tissue death and the spread of cancer outside the lymph node boundaries and other suspicious signs. The method has restricted diagnostic precision because it uses size and shape standards which do not work for cancer detection in typical lymph nodes and which wrongly identify noncancerous lymph nodes as cancerous. The ability of conventional imaging techniques to identify cervical metastasis combines with their capability to find hidden lymph node diseases which physical tests fail to detect.

Recently, functional imaging with positron emission tomography (PET), especially with fluorine-18 fluorodeoxyglucose ([18F]FDG), has gained attention in cancer imaging [6]. FDG-PET offers metabolic information by measuring the increased glucose metabolism in cancer cells, allowing detection of tumor activity before anatomical changes occur. When integrated with computed tomography (PET/CT), it provides metabolic and anatomical information, which may enhance diagnostic accuracy in the detection of primary tumors, lymph node metastases and distant metastases.

Researchers have studied how [18F] FDG PET imaging methods help assess the necks of oral squamous cell carcinoma patients who display no clinical symptoms. Some investigators have reported encouraging results, suggesting that FDG-PET may serve as a valuable adjunct in identifying occult metastases and guiding treatment decisions [7]. The studies show that PET/CT testing can effectively prevent unnecessary elective neck dissections by demonstrating that patients do not have nodal disease. The study findings showed conflicting results because researchers found it difficult to detect small metastatic deposits, which showed limited sensitivity, in clinically N0 patients. The researchers found study design differences and patient population differences and tumor characteristic differences and imaging protocol differences as the reasons for result variability.

The interpretation of FDG-PET imaging faces another challenge in areas that have a high occurrence of chronic granulomatous diseases which include tuberculosis [8]. The settings display false-positive results and decreased specificity because both inflammatory and infectious conditions show higher FDG uptake. The limitation affects developing countries which include India because granulomatous infections occur frequently and they can interfere with PET/CT results. The diagnostic value of FDG-PET/CT needs assessment in these situations to establish its actual medical significance.

Researchers need to conduct a complete comparative study which compares PET/CT with standard imaging techniques that include USG and CECT to evaluate the clinically N0 neck condition of patients who have upper aerodigestive tract squamous cell carcinoma. The comparison needs to identify which imaging method provides the highest accuracy at the lowest cost while maintaining clinical usefulness for finding hidden nodal spread. The research study provides critical insights into the problem because it investigates the medical testing methods which work efficiently in a community that experiences a high incidence of granulomatous diseases. The research study establishes essential medical guidelines that apply to specific geographical areas.

The current research aims to fill existing research voids by comparing the diagnostic accuracy of FDG-PET/CT with standard imaging methods which include USG and CECT for patients who exhibit clinically negative necks. The researchers present their study as one of the most extensive studies which have been conducted in the Indian subcontinent to show how these imaging techniques function in actual clinical situations.

Methodology

Study Design: This study was designed as a prospective, comparative, observational study aimed at evaluating the diagnostic accuracy of PET/CT in comparison with conventional imaging modalities, namely ultrasonography (USG) and contrast-enhanced computed tomography (CECT), for assessing clinically N0 neck in patients with upper aerodigestive tract squamous cell carcinoma.

Study Area: The study was conducted in the Department of Nuclear Medicine, tertiary care centre in India.

Study Duration: The study was carried out over a period of one year.

Study Participants

Inclusion Criteria

- Patients with histopathologically confirmed squamous cell carcinoma of the upper aerodigestive tract.
- Patients with clinically N0 neck (no palpable cervical lymph nodes).
- Patients who had not received prior treatment (surgery, chemotherapy, or radiotherapy) for head and neck cancer.
- Patients planned for surgical management including neck dissection.
- Patients willing to provide informed consent.

Exclusion Criteria

- Patients with clinically palpable or radiologically evident lymph node metastasis.
- Patients with known distant metastasis.
- Patients with previous treatment for head and neck malignancy.
- Patients with second primary tumors.
- Patients with severe comorbid conditions contraindicating imaging or surgery.
- Pregnant or lactating women.

Sample Size: A total of 80 patients fulfilling the inclusion criteria were enrolled in the study.

Procedure: After obtaining approval from the Institutional Ethics Committee and written informed consent from all participants, eligible patients were recruited. Detailed clinical history and examination were performed to confirm clinically N0 neck status. All patients underwent preoperative imaging evaluation within two weeks prior to surgery using USG, CECT, and 18F-FDG PET/CT. Ultrasonography of the neck was performed using a high-resolution linear probe by experienced radiologists to assess lymph node characteristics such as size, shape, echogenicity, and vascularity. Contrast-enhanced CT scan of the head and neck was conducted following intravenous administration of iodinated contrast material, and images were acquired from the skull base to the supraclavicular region. Criteria such as nodal size, central necrosis, and irregular margins were used to identify metastatic nodes.

For PET/CT imaging, patients were instructed to fast for at least 6 hours prior to the scan, and blood glucose levels were ensured to be below 140 mg/dl. Approximately 370 MBq (10 mCi) of 18F-FDG was administered intravenously, and imaging was performed after an uptake period of about 60 minutes using a dedicated PET/CT scanner. Whole-body scans from skull base to mid-thigh were acquired. PET/CT images were interpreted independently by two experienced nuclear medicine physicians who were blinded to the findings of USG and CECT. A standardized 5-point scoring system was used to categorize lymph nodes, with scores of 3 and 4 considered positive for malignancy. Following imaging, all patients underwent appropriate surgical management, including neck dissection. The extent of dissection was guided by imaging findings and intraoperative assessment. Excised lymph nodes were subjected to histopathological examination using hematoxylin and eosin staining, which served as the gold standard for comparison. Imaging findings from USG, CECT, and PET/CT were correlated with histopathological results for each patient.

Statistical Analysis: Data were entered and analyzed using SPSS version 27.0. Descriptive statistics were used to summarize patient characteristics. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of USG, CECT, and PET/CT were calculated using histopathology as the reference standard. Comparative analysis between imaging modalities was performed using the Chi-square test. A p-value of less than 0.05 was considered statistically significant.

Result

Table 1 shows the demographic and clinical characteristics of the study participants (n = 80). The majority of patients belonged to the 51–60 years age group (35%), followed by 61–70 years (27.5%), 40–50 years (22.5%), and those above 70 years (15%), with a mean age of 58.6 ± 9.4 years, indicating that most patients were in the late middle-aged to elderly category. A clear male predominance was observed, with 75% males and 25% females. Regarding the primary tumor site, the oral cavity was the most common (40%), followed by the larynx (25%), oropharynx (22.5%), and hypopharynx (12.5%). In terms of tumor staging, T2 stage was the most frequent (32.5%), followed by T3 (27.5%), while T1 and T4 stages were equally distributed at 20% each, suggesting that a substantial proportion of patients presented with moderately advanced disease.

Table 1: Demographic and Clinical Characteristics of Study Participants (n = 80)			
Variable	**Category**	**Number (n)**	**Percentage (%)**
Age (years)	40–50	18	22.5
	51–60	28	35
	61–70	22	27.5
	>70	12	15
Mean Age	—	58.6 ± 9.4	—
Sex	Male	60	75
	Female	20	25
Primary Site	Oral cavity	32	40
	Oropharynx	18	22.5
	Larynx	20	25
	Hypopharynx	10	12.5
T Stage	T1	16	20
	T2	26	32.5
	T3	22	27.5
	T4	16	20

Table 2 shows the distribution of histopathological findings, which served as the gold standard in the present study. Out of a total of 80 patients, 28 cases (35%) were found to be positive for occult metastasis, while the remaining 52 cases (65%) were negative. This indicates that a substantial proportion of clinically N0 neck patients actually harbored hidden metastatic disease that was not detected clinically or through initial imaging. The relatively high percentage of occult metastasis highlights the importance of accurate diagnostic modalities for early detection and appropriate management, as relying solely on clinical examination may underestimate the true disease burden.

Table 2: Histopathological Findings (Gold Standard)		
Result	**Number (n)**	**Percentage (%)**
Positive (Occult metastasis)	28	35
Negative	52	65
Total	**80**	**100**

Table 3 presents the contingency analysis comparing imaging findings (USG, CECT, and PET/CT) with histopathological results in detecting disease. For USG, out of 80 cases, 18 were true positives (TP) and 40 true negatives (TN), while 12 cases were false positives (FP) and 10 false negatives (FN), indicating moderate diagnostic performance with relatively higher false results. In comparison, CECT showed improved accuracy with 21 true positives and 44 true negatives, along with reduced false positives (8) and false negatives (7). PET/CT demonstrated the best diagnostic performance among all modalities, with the highest true positives (25) and true negatives (48), and the lowest false positives (4) and false negatives (3). Overall, PET/CT exhibited superior diagnostic reliability, followed by CECT, while USG showed comparatively lower accuracy in correlating with histopathological findings.

Table 3: Contingency Table (Imaging vs Histopathology)			
USG			
	Histopath Positive	**Histopath Negative**	**Total**
Positive	18 (TP)	12 (FP)	30
Negative	10 (FN)	40 (TN)	50
Total	28	52	80
CECT			
	Histopath Positive	**Histopath Negative**	**Total**
Positive	21 (TP)	8 (FP)	29
Negative	7 (FN)	44 (TN)	51
Total	28	52	80
PET/CT			
	Histopath Positive	**Histopath Negative**	**Total**
Positive	25 (TP)	4 (FP)	29
Negative	3 (FN)	48 (TN)	51
Total	28	52	80

Table 4 demonstrates the comparative diagnostic performance of different imaging modalities, showing that PET/CT outperformed both USG and CECT across all evaluated parameters. The sensitivity was highest for PET/CT (89.3%), followed by CECT (75%) and USG (64.3%), indicating a superior ability of PET/CT to correctly identify true positive cases. Similarly, specificity was also greatest in PET/CT (92.3%), compared to CECT (84.6%) and USG (76.9%), reflecting its better accuracy in ruling out disease among true negatives. Overall diagnostic accuracy followed the same trend, with PET/CT achieving 91.3%, which was markedly higher than CECT (81.3%) and USG (72.5%). These findings suggest that PET/CT is a more reliable imaging modality for detecting and excluding disease compared to conventional imaging techniques.

Table 4: Diagnostic Performance of Imaging Modalities

Parameter	USG (%)	CECT (%)	PET/CT (%)
Sensitivity	64.3	75	89.3
Specificity	76.9	84.6	92.3
Accuracy	72.5	81.3	91.3

Table 5 demonstrates the comparative predictive values of USG, CECT, and PET/CT in assessing clinically N0 neck in upper aerodigestive tract squamous cell carcinoma. The Positive Predictive Value (PPV) was highest for PET/CT (86.2%), followed by CECT (72.4%) and USG (60%), indicating that PET/CT is more reliable in correctly identifying true positive cases of nodal metastasis. Similarly, the Negative Predictive Value (NPV) was also greatest for PET/CT (94.1%), compared to CECT (86.3%) and USG (80%), suggesting its superior ability to accurately rule out disease in negative cases. Overall, PET/CT exhibited better diagnostic confidence than conventional imaging modalities, with higher PPV and NPV, thereby supporting its role as a more effective tool in evaluating clinically negative neck nodes.

Table 5: Predictive Values

Parameter	USG (%)	CECT (%)	PET/CT (%)
Positive Predictive Value (PPV)	60	72.4	86.2
Negative Predictive Value (NPV)	80	86.3	94.1

Discussion

The present study shows that detecting hidden cervical lymph node metastasis from upper aerodigestive tract squamous cell carcinoma requires precise detection methods for patients who present with N0 neck conditions. Our study discovered that 35% of patients experienced hidden metastasis, which matches the previously documented rates that range from 24% to 50% for this specific patient group (Zbären et al., 2006; Spiro et al., 1996) [9,10]. The similarity between the two groups confirms that most patients with negative necks actually have hidden medical conditions, which doctors need to check during their assessment of cases that reach T2 through T3 stages, according to our research results. The study results show that clinical examination methods cannot detect all conditions, which creates a need for advanced testing methods that can identify medical issues.

The results of our study showed that PET/CT provided better sensitivity and specificity and overall diagnostic accuracy when compared to USG and CECT. The research done by Ng SH Yen et al. (2005) [11] showed that PET could detect nodal metastasis with higher diagnostic accuracy than CT and MRI because PET had sensitivity rates between 67 and 96 percent and specificity rates between 82 and 100 percent. According to Menda Y and Graham (2005) [12] research FDG-PET produces better staging results because it can identify metabolic activity whereas traditional methods only show physical changes which fall behind actual biological changes in cancerous cells. The study demonstrates that PET/CT produces the best predictive results because it achieves a high negative predictive value (NPV) which helps doctors determine whether a patient has metastasis and prevents them from undergoing unnecessary surgical procedures.

The meta-analysis results from de Bondt RB et al. (2007) [13] show that USG has lower sensitivity and specificity results because our study found these measurements to be lower than the 60% sensitivity and 77% specificity results that ultrasound showed. The diagnostic accuracy of USG testing depends on the ability of the operator to perform the test because the method provides low-cost and non-invasive testing. The research conducted by van den Brekel MW et al. (2000) [14] shows that using fine-needle aspiration cytology (FNAC) together with USG improves diagnostic results, which means that doctors should use both methods instead of relying solely on USG for evaluating clinically N0 neck patients.

CECT showed better results than USG according to our research but its performance did not reach the standard set by PET/CT. Our findings match the results from Som PM et al. (2000) [15] who showed that CT-based nodal assessment depends mainly on size criteria and morphological features which show limitations when detecting micrometastases in lymph nodes that measure less than 10 mm. The restriction affects head and neck cancers because most metastatic spread occurs through small lymph nodes which makes CT imaging less effective at detecting metastatic spread.

The research findings demonstrate that PET/CT imaging delivers better positive predictive value (PPV) and negative predictive value (NPV) results when compared to standard imaging techniques. The study results demonstrate that PET/CT technology shows high positive predictive value and negative predictive value which helps doctors make accurate disease assessments according to Stoeckli SJ et al. (2002) [16]. PET/CT technology provides excellent diagnostic capabilities yet it has certain restrictions that limit its effectiveness. The research by Brouwer J et al. (2004) demonstrates that PET/CT technology cannot detect small-volume metastatic disease because of its spatial resolution limits which result in false-negative detection. The results of our study showed that a small number of cases remained undetected even after doctors performed PET/CT tests.

The clinical value of PET/CT for changing treatment methods continues to be debated in medical circles. Our research demonstrates that PET/CT offers better diagnostic performance, but Wensing et al. (2012) [17] display guidelines which show that the method has not yet become standard practice for all staging procedures in developing nations. The phenomenon occurs because false-positive results emerge from high-cost testing which detects diseases that cause similar symptoms to cancer through FDG uptake.

The research results show strong agreement with existing research because PET/CT detects hidden neck metastasis better than USG and CECT. The study results demonstrate that our research method functions as an effective preoperative staging tool because it achieves better testing results through its increased sensitivity and specificity and predictive value. The method should not be used in standard practice because it has two main drawbacks which include its decreased ability to detect micrometastases and its high operational costs. The best method for staging and treating head and neck cancers combines clinical assessment with standard imaging techniques and targeted PET/CT scanning.

Conclusion

The present study demonstrates that a significant proportion of patients with clinically N0 neck harbor occult cervical lymph node metastasis, emphasizing the limitations of clinical examination alone. Among the imaging modalities evaluated, PET/CT showed superior diagnostic performance with the highest sensitivity, specificity, and overall accuracy, making it a more reliable tool for detecting and ruling out nodal disease compared to USG and CECT. Its high negative predictive value suggests a potential role in reducing unnecessary elective neck treatments. However, limitations such as false negatives in micrometastasis and cost considerations must be acknowledged. Therefore, PET/CT should be used as a valuable adjunct rather than a replacement, with a combined, multimodal approach offering the most effective strategy for accurate staging and optimal patient management.

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