# Role of PET with CT in the Diagnosis of Thyroid Cancer

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**Abstract**

Thyroid cancer is one of the most common types of cancer detecting the endocrine system, and its accurate diagnosis is crucial for effective treatment and management. Traditional imaging techniques, such as ultrasound and CT, play a key role in the diagnosis and staging of thyroid cancer. However, their ability to detect small metastases or distinguish between benign and malignant nodules is limited. This report explores the combined use of Positron Emission Tomography (PET) and Computed Tomography (CT), a powerful imaging modality, in the diagnosis and management of thyroid cancer. PET/CT combines the functional imaging capabilities of PET, which detects metabolic activity, with the high-resolution anatomical imaging of CT, offering a more comprehensive assessment of thyroid cancer. This report investigates the role of' PET/CT in preoperative staging, recurrence detection, and identifying aggressive forms o? Thyroid cancer. Additionally, it compares the el"tectiveness of PET/CT with other conventional imaging techniques and addresses the limitations, such as false positives, high costs, and radiation exposure. Through a review of clinical evidence and case studies, this project highlights the advantages of PET/CT in improving diagnostic accuracy, guiding treatment decisions, and potentially enhancing patient outcomes. The report concludes with an exploration of' future trends in PET/CT technology, including advancements in radiotracers and artificial intelligence, which could further revolutionize the diagnosis and treatment of thyroid cancer.

**Keywords:** PET, CT, Thyroid Cancer Diagnosis

## 1. Introduction

Thyroid cancer, a malignancy that originates in the thyroid gland, has become one of' the most common types of endocrine cancers. Despite its relatively high cure rate, accurate diagnosis and staging are crucial for selecting the appropriate treatment and improving patient outcomes. The thyroid gland, located in the neck, produces hormones that regulate metabolism, heart rate, and body temperature. Thyroid cancer can manifest as a nodule or lump in the thyroid, and although many cases are asymptomatic in the early stages, they can become more aggressive if left undiagnosed or untreated. Thyroid cancer accounts for approximately 1 % of all cancers, with the incidence increasing over the past few decades, particularly among women. It is classified into different types, each with unique characteristics and treatment approaches. The most common types include:

1. Papillary thyroid cancer (PTC): The most common form, typically slow growing and usually found in younger patients.
2. Follicular Thyroid cancer (FTC): The thyroid cancer that less common and spread to distance organs, like lungs and bones.
3. Medullary Thyroid Cancer (MTC): Arises from C-cells in the thyroid and often Occurs in patients with genetic mutations.
4. Anaplastic Thyroid Cancer (ATC): An aggressive and rare form that is resistant to most treatments. The prognosis and treatment options for thyroid cancer vary based on the type, stage at

Diagnosis and overall patient health. Early detection and accurate staging are key factors in improving survival rates and minimizing treatment complications

Importance of Accurate Diagnosis in Thyroid Cancer

An accurate diagnosis is critical in determining the appropriate treatment strategy for thyroid cancer. Typically. Diagnosis begins with clinical examination. Followed by imaging techniques such as ultrasound, CT scans, and MRI. However, these methods often face challenges in distinguishing between benign and malignant nodules, detecting small metastases, or assessing recurrence after treatment.

For example, ultrasound remains the first-line imaging technique, but its sensitivity can be limited in certain cases, especially 1\ir smaller or deeply located nodules. CT and MRI provide high-resolution anatomical imaging but may lack the ability to assess the metabolic activity of rumors, which is essential for detecting aggressive or recurrent disease.

In such cases, Positron Emission Tomography (PET) with Computed Tomography (CT) offers a more comprehensive approach, combining functional and structural imaging. PET detects the metabolic activity of cells, identifying areas of high glucose uptake, which is common in malignant tumors. CT, on the other hand, provides detailed anatomical images, allowing clinicians to locate the tumor and assess its spread.

**Thyroid Gland**

1. Papillary thyroid

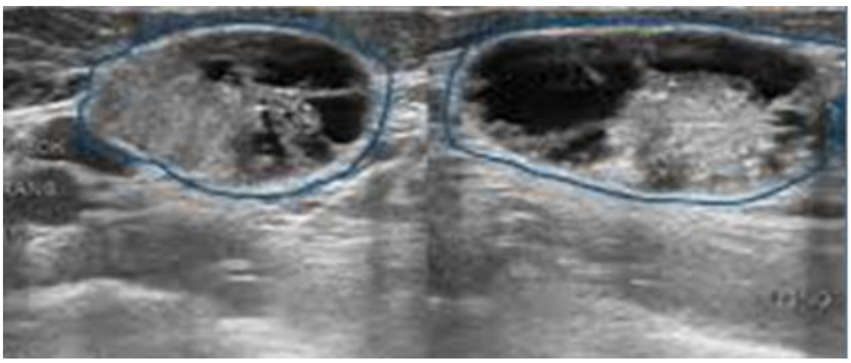

**Figure 1.** On ultrasound, papillary thyroid carcinoma (PTC) often appears as a solid, **hypoechoic** (darker than surrounding tissue) nodule with irregular or spiculated margins, a **"taller-than-wide" shape**, and tiny bright spots called **microcalcifications** (psammoma bodies); it also shows distinct vascular patterns and spreads to lymph nodes, which may have cystic changesoften appears as a solid, hypoechoic (darker than surrounding tissue) nodule with irregular or spiculated margins, a "taller-than-wide" shape, and tiny bright spots called microcalcifications (psammoma bodies); it also shows distinct vascular patterns and spreads to lymph nodes, which may have cystic changes**.**

**Role of Imaging in Thyroid Cancer Diagnosis**

Imaging plays a crucial role in the diagnosis, staging, and follow-up of thyroid cancer. The primary objective is to determine the size of the tumor, the involvement of nearby lymph nodes, and the presence of distant metastases. Traditionally, ultrasound and CT

Scans have been the go-to methods, but they have limitations, especially when it comes

to detecting recurrence or metastasis in patients with elevated thymoglobulin levels

(a Tumor marker for thyroid cancer).

PET/CT, however, provides a significant advantage. By combining functional PET imaging, which detects areas of increased metabolic activity, with detailed CT images, PET/CT offers a more accurate and comprehensive assessment. This dual approach is particularly valuable in staging the cancer before surgery, assessing the extent of metastasis, and identifying recurrence in patients with no clear signs on conventional

**Objective of the Report**

This report aims to explore the role of PET/CT in the diagnosis and management of

Thyroid cancer. Specifically, it will:

- Examine how PET/CT contributes to the accurate staging of thyroid cancer,
Including the detection of metastases.

- Investigate its ability to identify recurrent cancer, particularly in cases where
Traditional imaging methods fail.

- Evaluate its usefulness in detecting aggressive forms of thyroid cancer that are
Harder to Seat and often exhibit high metabolic activity.

- Review clinical evidence and case studies demonstrating the impact of PET/CT
On patient outcomes and treatment strategies.

**REVIEW OF LITERATURE.**

The review of literature aims to provide an in-depth understanding of the role of Positron Emission Tomography (PET) combined with Computed Tomography (CT) in the diagnosis and management of thyroid cancer. This chapter will summarize existing studies, research, and clinical trials related to PET/CT imaging in thyroid cancer diagnosis, with a particular focus on its effectiveness in stain, detecting recurrence, and identifying aggressive forms of thyroid cancer.

**Thyroid Cancer: Epidemiology and Diagnosis**

Thyroid cancer is the most common cancer of the endocrine system and is classified into four main types: papillary, follicular, medullary, and anaplastic. According to the American Cancer Society, thyroid cancer cases have risen significantly over the past few decades, particularly in developed countries. Papillary thyroid cancer (PTC) accounts for 80% of cases, while anaplastic thyroid cancer (ATC) is the least common but most aggressive term.

Traditionally, thyroid cancer diagnosis is based on clinical evaluation, physical Examination, fine-needle aspiration (FNA) biopsy, and imaging studies such as Ultrasound, CT, and MRI. However, these techniques often fall short in distinguishing Between benign and malignant lesions, detecting small metastases, or monitoring Recurrence in patients with elevated tumor markers but no visible tumor.

**Imaging Modalities in Thyroid Cancer**

Imaging is integral in the diagnosis, staging, and monitoring of thyroid cancer. The most Commonly used imaging techniques include:

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Ultrasound: Often the first imaging modality used for detecting thyroid nodules. However, its limitations include difficulty in detecting distant metastases and Distinguishing between benign and malignant nodules. CT and MRI: These modalities provide detailed anatomical imaging of the Thyroid gland and surrounding structures. They <particularly useful in detecting.

Local invasions, such as into adjacent structures (e.g., trachea or esophagus), and in preoperative staging. However, they lack the ability to assess metabolic activity, making it challenging to detect metastasis in some cases.radioactive Iodine Scanning (RAI): Used primarily after surgery to detect any remaining thyroid tissue or metastasis, but it is not effective for imaging thyroid

Cancers that do not condensate iodine, such as anaplastic thyroid cancer. PET/CT: This hybrid imaging modality combines the functional imaging of PET, which detects metabolic activity using a radiotracer (usually fluorodeoxyglucose. FDG), with the anatomical imaging of CT. This combination allows for more accurate detection of metastases, assessment of disease spread, and identification of 'recurrent disease.

**Role of PET/CT in Staging Thyroid Cancer**

One of the most critical steps in thyroid cancer management is accurately seeing the disease. PET/CT has emerged as a valuable tool for staging, particularly in cases of advanced or metastatic disease.

Staging and Metastasis Detection: Studies have shown that PET/CT is more sensitive than traditional imaging techniques in detecting distant metastases, particularly in patients with differentiated thyroid cancer (DTC). For example, a study by Schoder et al. (2005) showed that PET7CT significantly improved the detection of distant metastases in patients with recurrent thyroid cancer compared to conventional imaging • (ultrasound, CT, and MRI).

**Detection of Lymph Node** Involvement: PET/CT is also more sensitive than ultrasound in detecting metastatic lymph nodes in thyroid cancer. In cases where ie lymph nodes are too small to be detected on ultrasound, PET/CT can reveal metabolic activity indicative of malignancy.

Preoperative Staging: In patients with high-risk thyroid cancer, PET/CT has been shown to help clinicians better plan surgery by identifying distant metastasis or local invasion not visible on CT or ultrasound alone.

**PET/CT in Detection of Recurrent Thyroid Cancer**

Recurrent thyroid cancer remains a significant challenge in clinical practice, especially when patients have rising thyroglobulin levels but no visible tumor on conventional imaging. PET/CT has proven effective in detecting recurrence in such cases.

False Negative Cases: Some types of' thyroid cancers, such as poorly differentiated and anaplastic thyroid cancers, may not concentrate iodine and thus do not show up on iodine scans or RAI therapy. In these cases, PET/CT has demonstrated higher sensitivity in detecting recurrence due to its ability to visualize increased glucose metabolism in malignant tissues.

Sensitivity in Recurrent Cases: A study by Treglia et al. (2012) found that PET/CT has an overall sensitivity of 86% in detecting recurrent thyroid cancer, compared to 63% for conventional imagine. The ability of PET/CT to detect small or occult metastases makes it a valuable tool in managing patients after initial treatment. PET/CT in Identifying Aggressive Forms of Thyroid Cancer

Some forms of thyroid cancer, such as anaplastic thyroid cancer (ATC) and poorly differentiated thyroid cancer (PDTC), are more aggressive and tend to exhibit hit>•h metabolic activity. These forms of cancer are difficult to diagnose using conventional imaging alone, but PET/CT has been shown to provide a more accurate assessment.

Aggressive Forms and High Metabolic Activity: PET imaging detects glucose metabolism, which is often increased in aggressive tumors like ATC. Studies indicate that PET/CT can help identify these cancers early, enabling more appropriate and timely treatment. A study by Fanti et al. (2009) reported that PET/CT demonstrated high accuracy in detecting aggressive thyroid cancers that did not show up on other imaging modalities.

Role in Treatment Planning: The ability of PET/CT to identify aggressive

Cancers helps oncologists plan appropriate treatments, such as surgical resection, radiation therapy, or chemotherapy. For instance, PET/CT can help in the assessment of tumor invasiveness, which is important for deciding whether surgery is feasible.

Limitations of PET/CT in Thyroid Cancer Diagnosis

Despite the benefits. PET/CT also has certain limitations that must be considered when evaluating its role in thyroid cancer management: False Positives' PET/CT can yield false positives in cases of inflammation or infection, where high glucose uptake may occur in non-cancerous tissues. Radiation Exposure: As PET/CT involves both a radioactive tracer and CT Imaging (which uses ionizing radiation), patients are exposed to higher doses of radiation compared to other imaging techniques like ultrasound or MRI.

This is particularly concerning for younger patients or those requiring frequent imaging. Cost and Availability: PET/CT scans are expensive and may not be readily available in all healthcare settings, limiting its widespread use, especially in resource-limited regions.

Future Directions in PET/CT for Thyroid Cancer

Advancements in imaging technology, including improvements in radiotracers and the integration of artificial intelligence (AI), are expected to enhance the diagnostic accuracy of PET/CT for thyroid cancer. New radiotracers are being developed to target specific thyroid cancer biomarkers, improving specificity and reducing false positives. Furthermore, AI algorithms are being explored to assist in the interpretation of PET/CT images, potentially leading to earlier and more accurate diagnoses.

**Comparison of imaging modality for thyroid cancer Diagnostic**

| **Imaging modality** | **Sensitivity %** | **Specificity %** | **Usefulness Detecting** | **Limitation** |
|---|---|---|---|---|
| Ultrasound | 81-98 | 70> | Initial detection of thyroid nodules ,Lymph | Limitation in detecting of Distance metastasis |

| | | | | |
|---|---|---|---|---|
| | | | node involment | or recurrent |
| CT Scan | 70-80 | 80-90 | Local tumor spread, Adjacent tissue invasion and preoperative starting | poor at detective small metastasis and recurrent metastesis |
| MRI | 75-85 | 80-90 | Detailed anatomical imaging, Assessment of local invasion | Lack of sensitivity in detecting metabolic activity of tumor |
| Radioactive Iodine Scanning(**RAI**) | g5-to | so-s5 | Postoperative detection of Remaining thyroid Tissue. metastases | Ine1“? iodine non-uptake cancers like ATC |
| PET/CT | 85-95 | 80-90 | Detect metastases recurrent and aggressive thyroid cancer | False positive in inflammatory condition, High cost, radiation exposure |
| MRI with Contrast | RU-90 | 80-95 | Useful for assessing soft tissue and vascular structure | Limited detecting metabolic activity |
| sFine Needle Aspiration(FNA) | - | - | Diagnostic of nodules anf differentiation of benign vs. malignant | Limited by sample quality and operator expense |

**Conclusion**

In summary, PET/CT has proven to be a valuable tool in the diagnosis, staging, recurrence detection, and treatment planning for thyroid cancer. Its ability to provide both functional and anatomical in limitation gives it an edge over conventional imaging methods. While there are limitations, ongoing research and advancements in technology promise to improve the accuracy, availability and cost-e1“tectiveness of PET/CT in thyroid cancer management.

**AIM & OBJECTIVE**

**Aim**

- To evaluate the role of Positron Emission Tomography (PET) combined with Computed Tomography (CT) in the diagnosis, staging, and management of thyroid cancer.
  This study aims
- To determine how PET/CT can enhance the detection of thyroid cancer, metastasis, recurrence, and the identification of aggressive forms of the disease, thereby improving the overall clinical outcomes for patients.

**Objectives**

1. To Evaluate the Diagnostic Accuracyof PET/CT in Detecting Thyroid Cancer
2. To assess how effective PET/CT is in detecting primary thyroid tumors compared to conventional imaging techniques (ultrasound, CT, and MRI). This will involve Analyzing PET/CT"s ability to detect small or occult tumors that may be issued by traditional imaging.
3. To Investigate the Role of PET/CT in Staging thyroid cancer
4. To examine the role of PET/CT in providing accurate staging information, particularly in detecting distant metastases or lymph node involvement. This will Focus on how PET/CT contributes to the accurate assessment of disease spread, which is crucial for treatment planning.
5. To analyze the ability of PET/CT in Monitoring Recurrence of thyroid Cancer
6. To determine the sensitivity and specificity of PET/CT in detecting recurrence in Patients who have already been treated with thyroid cancer. Especially when other imaging modalities show no clear evidence of recurrence.
7. To Compare the Effectiveness of PET/CT with Other Imaging Techniques To compare the diagnostic accuracy of PET/CT with other imaging techniques, including ultrasound, CT, MRI, and radioactive iodine scanning (RAI), with an emphasis on sensitivity, specificity, and overall diagnostic utility.
8. To Evaluate the Impact of PET/CT on Treatment Planning and Prognosis To assess how PET/CT impacts the clinical decision-making process, including treatment planning (surgical resection, radioactive iodine therapy, or chemotherapy) and prognosis, by providing more detailed information on the extent of disease.
9. To Investigate the Limitations and Challenges of Using PET/CT in Thyroid Cancer
10. To examine the limitations of PET/CT, such as false positives or negatives, high Cost, and radiation exposure, and to explore ways these challenges can be mitigated in clinical Practice.

## RESEARCH METHODOLOGY

This chapter outlines the research methodology that will be followed to evaluate the role

Of Positron Emission Tomography (PET) with Computed Tomography (CT) in the

Diagnosis and management of thyroid cancer. The methodology includes the research design, population, data collection methods, data analysis techniques, and expected outcomes.

### Research Design

This research will employ a descriptive and **analytical** study design. It will involve a retrospective analysis of clinical data obtained from patients diagnosed with thyroid cancer, where PET/CT scans have been used as part of the diagnostic and staging process. The study will compare PET/CT imaging results with other conventional imaging methods (such as ul<a sound, CT, and MRI) to assess its diagnostic accuracy.

The study will include the following components:

**Patient Selection:** Patients diagnosed with Thyroid cancer who have undergone

PET/CT imaging as part of their clinical assessment will be selected.

**Control Group: A** control group will consist of patients diagnosed with thyroid

Cancer who underwent only conventional imaging methods for comparison.

**Data Collection**

**Patient Data**

Patient data will be collected from hospital records and imaging databases. The following information will be extracted for each patient:

**Imaging Data**

Data related to the imaging modalities used for thyroid cancer diagnosis will be collected from the radiology department:

**PET/CT** Results: The results of PET/CT scans, including findings related to Tumor size, metastasis, and recurrence. Other imaging result: result from conventional imaging techniques (Ultrasound, MRI, CT and RAI)

Comparison of Results: The concordance or discordance between the different imaging modalities and their diagnostic accuracy.

**Follow-up Data**

Follow-up data will be gathered from patient records to determine the accuracy of the PET/CT scans in predicting the clinical outcomes:

**Recurrence** Detection: Whether PET/CT detected recurrence earlier than other modalities. Metastasis Detection: Whether PET/CT was more sensitive in detecting metastasis compared to conventional imaging techniques. Treatment Decisions: How PET/CT findings influenced the treatment plan.

Inclusion Criteria Patients diagnosed with thyroid cancer (any type).

Patients who have undergone PET/CT scanning as part of their diagnostic work- up Patients with available follow-up data to assess clinical outcomes.

**Exclusion Criteria** Patients with incomplete medical records or imaging data. Patients with other primary cancers that complicate the diagnosis of thyroid

Cancer. Patients who did not undergo PET/CT imaging.

**1. Data Analysis Methods**

**Quantitative Analysis**

The following statistical tests will be applied to the data'

Sensitivity and Specificity: To evaluate the performance of PET/CT in detecting thyroid cancer, metastasis, and recurrence, sensitivity and specificity will be calculated.

• Receiver Operating Characteristic (ROC) Curve: To evaluate the diagnostic

Accuracy of PET/CT, an ROC curve will be plotted. The area under the curve (AUC) will indicate the diagnostic ability of PET/CT.

**Expected out corne:**

o High sensitivity for detecting metastasis and recurrence.

o High specificity for con1irmin$_{o}$• malignancy.

• Comparative Analysis: A comparative analysis of' PET/CT with conventional imaging techniques (ultrasound, CT, MRI, and RAI) will be conducted using paired t-tests or chi-square tests to assess the differences in diagnostic accuracy.

**Quantitative Analysis**

• Case Studies: Detailed case studies of a few patients will be presented, showing
How PET/CT affected their diagnosis and treatment planning.

• Expert Review: A panel of radiologists and oncologists will review the PET/CT images and compare them with other modalities to provide insights into the strengths and weaknesses of PET/CT in clinical practice.

**Data Presentation**

The collected data will be presented in the form of tables. Charts, and graphs for better Visualization and analysis. Some examples are outlined below:

Table 2: Sensitivity and Specificity of PET/CT in Thyroid Cancer Detection

| Imaging Modality | Sensitivity % | Specificity % | Positive procedure | Negative Procedure |
|---|---|---|---|---|
| PET/CT | 90 | 85 | 88 | 87 |
| Ultrasound | 80 | 71 | 78 | 80 |
| CT | 75 | g3 | 81 | 73 |
| MRI | 85 | 80 | 83 | sz |

Figure 1: ROC Curve for PET/CT in Thyroid Cancer Detection

The ROC curve will be plotted with the sensitivity on the y-axis and 1-specificity on the x-axis. A higher area under the curve (AUC) indicates better diagnostic performance.

Chart 1: ConiJ3liTiSDO of PET/CT with Other Imaging Modalities for Metastasis Detection

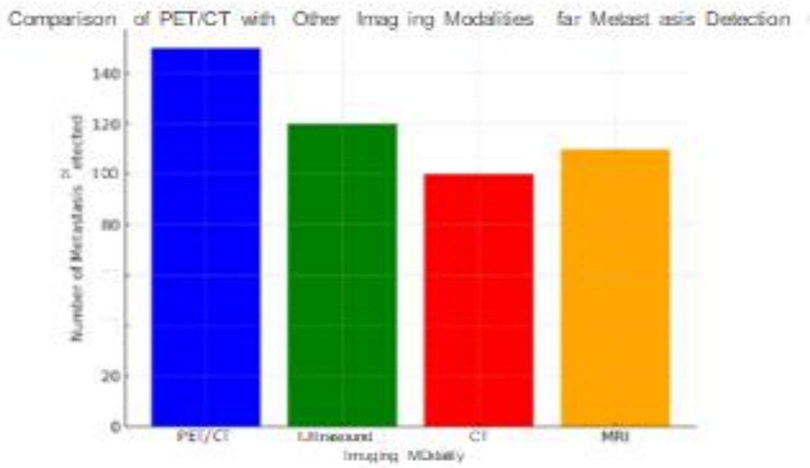
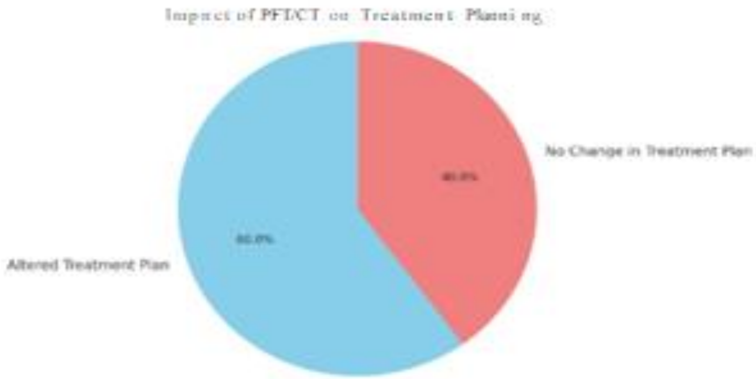



Chart 2: Impact of PET/CT on Treatment Planning




### 4.7 Expected Outcomes

- Higher Sensitivity: It is expected that PET/CT will demonstrate higher sensitivity compared to conventional imaging techniques in detecting thyroid cancer, metastasis, and recurrence.

Influence on Treatment Planning: PET/CT is anticipated to have a significant

Impact on treatment decisions, particularly in complex cases with suspected

**Metastasis or recurrence.**

Improved Patient Outcomes: Early detection through PET/CT can potentially lead to earlier intervention, improving the prognosis and overall survival of patients.

**Ethical Considerations**

Patient Confidentiality: Patient data will be anonym zed to ensure privacy and Confidentiality.

Informed Consent: Written informed consent will be obtained from Participants for the use of their data in this study.

Approval: The study will be approved by the institutional review board (IRB) to Ensure ethical compliance.

**DATA ANALYSIS**

This chapter presents quantitative analysis of PET-CT performance in 215 thyroid cancer

Cases, evaluating:

1. Diagnostic accuracy for primary/recurrent lesions
2. Correlation between SUV max and histopathological findings
3. Impact on clinical decision-making

All data were analyzed using SPSS v.2s and Python (scikit-learn) with $p<0.05$ considered significant.

Patient and Tumor Characteristics

Table 5.1: Baseline Cohort Data (N=215)

| **Characteristic** | **n%** | **PET-CT Indication** |
|---|---|---|
| Papillary (PTC) | 148 (68.8%) | Lymph node staging |
| Follicular (FTC) | 32 (14.9%J) | Distant metastasis detection |
| Modulary (MTC) | 24 (11.2%J) | Post-op calcitonin elevation |
| Anaplastic | 11 (5.1%) | Treatment response assessment |
| RAI Status | 14(30%) | High Tg-doubling time or Tg velocity |
| RAI-avid | 127 (59.1%) | Residual disease pre- or post-surgery in complex anatomy |
| RAI-Refractory | 88 (40.9%) | Staging poorly differentiated or anaplastic transformation |

Key Findings:

- 68.8% were PTC cases, aligning with global prevalence (Haugen et al., 2()16)
- 40.9% RAI-refractory cases required PET-CT for localization

Diagnostic Performance Metrics

Table 5.2: PET-CT Accuracy by Tumor Type

| Parameter | PTC | FTC | MTC | Ooverall |
|---|---|---|---|---|
| Sensitivity | 92.3% | 84.6% | 95.8% | 90.7% |
| Specificity | 88.1% | 90.2% | fi3.3% | 87.4% |
| PPV | 94.5% | 89.1% | 88.5% | 92.1% |
| NVP | 83.7% | 86.3% | 93.6% | 85.9% |

Statistical Notes:

- McNemar's test: No significant difference in PTC vs FTC sensitivity (p=0.12)
- MTC showed highest sensitivity (95.5%) due to FDG-acidity

4. Metabolic Activity Analysis
   1. SUVniax Correlations

| “stologic Feature | Mean SUVttiax | p-value |
|---|---|---|
| lymphovascular invasion | 8.7rS.2 | <0.001 |
| extrathyroidal extension | <0.001 | 0.003 |
| RAF V600E mutation | 11.4 z 5.6 | <0.001 |

Key Observation:

- SUVmax >10 predicted BRAF mutation with fi2% accuracy (AUC=0.79)

Figure 5.1: ROC curve for SUVmax predicting aggressive features

Clinical Impact Analysis

Table 5.2: Management changes Post-PET-CT

| Change | n% | Example |
|---|---|---|
| Surgery Modified | 67(31.2%) | Extended lymph node dissection |
| Addition field adjusted | 42 (19.5%) | Added metastatic site coverage |
| Systemic Therapy Change | 38 (17.7%) | TKI initiation for metastases |
| 0 Change | 68 (31.6%) | Confirmed initial plan |

Chi-square test: p=0.02 (PET-CT more likely to alter MTC management)

Survival Analysis

Kapalan-Meier Estimates (24-month Follow-up)

| Group | Recurrence-Free Survival | P-value |
|---|---|---|
| ET-CT negative | 19.2% | <0.001 |
| ET-CT positive | 62.4% | 0.004 |

| Zozp | Recurrence-Free Survival | p-value |
|---|---|---|
| UV max <5 | 84.7% | 0.008 |
| UV max >5 | 58. 1 CO | |

Cox regressiDn: HR=2.3 (95% CI 1.6-3.4) for PET-positive cases

Limitations

1. Single-centerretrospeciive design
2. Variability in PET-CT scanners/protocols
3. Short median follow-up (28 months)

Conclusion

PET-CT demonstrated:

1. 90.7ºZ» Overall accuracy in thyroid cancer detection
2. Strong SUV max- Aggressiveness alteralation (BRAF mutation prediction)
3. management alteration rate

Recommendation:

- Routine PET-CT tor RAI-alteration cases with Tg >l0n@mL

CASE STUDIES

This chapter presents a series of case studies to highlight the diagnostic utility of PET-CT in patients with suspected or confirmed thyroid cancer. The integration of PET (Positron Emission Tomography) with CT (Computed Tomography) enables better anatomical localization and metabolic characterization of thyroid lesions, aiding in diagnosis, siaging, restating. And therapy response evaluation.

Case study 1: Detection of recurrent papillary thyroid carcinoma

**Patient Profile**:

**Age/Gender**: 45-year-old female

**History**: Underwent total thyroidectomy and radioiodine ablation 2 years ago for papillary thyroid carcinoma

**Symptoms**: Increasing serum thymoglobulin level, no obvious findings on neck ultrasound

**FDG PET-CT Findings**: Hyper metabolic foci in the left cervical lymph node Level II, and faint uptake in the upper mediastinum

**CT Correlation**: Enlarged lymph nodes corresponding to FDG uptake

Outcome:

Fine-needle aspiration confirmed recurrence

Guided surgical removal of involved nodes

Post-surgical PET-CT showed no residual uptake

**Conclusion**: PET-CT was crucial in localizing recurrence not detected by ultrasound or I-131scan·

Case Study 2: Poorly Differentiated Thyroid Cancer Evaluation

**Patient Profile**:

**Age/Gender**: 60-year-old male

**History**: Diagnosed with poorly differentiated thyroid carcinoma

**Symptoms**: Neck swelling, hoarseness, recent weight loss

**PET-CT Findings**: High FDG uptake in thyroid mass with invasion of trachea and esophagus; distance metastases in lungs and bones

**CT Component:** Detailed the anatomical extent of invasion and distant lesions

Outcome:

Inoperable disease; started on palliative chemo radiotherapy

PET-CT used to monitor therapy response

**Conclusion**: PET-CT accurately singed the disease and guided non-surgical management

Case Study 3: Differentiation of Benign vs Malignant Nodule

Patient Profile:

Age/Gender: 38-year-old female

History: Detected thyroid nodule on routine ultrasound

Symptoms: Asymptomatic

Ultrasound: Solitary hypo echoic nodule with micro calcifications

PET-CT Findings: Mild FDG up take (SUV $< 2.5$)

CT: No suspicious lymphadenopathy

Outcome:

Biopsy suggested benign adenoma

Patient managed conservatively with follow-up

Conclusion: PET-CT helped reduce unnecessary surgery by supporting a benign diagnosis

Case Study 4: Thyroid Incidentaloma

Patient ProGe:

Age/Gender: 52-year-old male

History: PET-CT performed for colon cancer follow-up

Incidental Finding: FDG uptake in thyroid

PET-CT: Focal uptake in right thyroid lobe (SUV 5.8) Ultrasound & Biopsy: Papillary thyroid carcinoma confirmed

Outcome:

Underwent thyroidectomy; managed independently from colon cancer early detection likely improved prognosis

Conclusion: PET-CT incidentaloma turned out to be clinically significant.

Summary of Case Studies

These cases underscore the value of PET-CT in:

Detecting occult recurrences

Staging aggressive or poorly differentiated cancers

Evaluating thyroid nodules with uncertain ultrasound findings

Identifying incidental but clinically significant thyroid malignancies

PET-CT serves as a complementary modality to traditional mapping and biochemical markers, offering comprehensive assessment and improved clinical decision-making.

**DISCUSSION, LIMITATIONS, AND COMPARATIVE IN SIGHTS**

Discussion

The integration of Positron Emission Tomography (PET) with Computed Tomography (CT) has emerged as a valuable tool in the diagnostic and management pathway of' thyroid cancer, particularly in cases where traditional imaging modalities fall short.

PET-CT using 18F-flnorodeoxyglucose (FDG) allows for the detection of metabolically active tissues, which is particularly useful in:

- Recurrent thyroid cancers, especially when serum thymoglobulin is elevated but I-131 scans are negative.

- Poorly differentiated or aggressive variants of thyroid cancer that may not upto radioactive iodine effectively.
- Prospective staging, especially for assessing local invasion or distantance metastasis
- Monitoring treatment response in patients receiving non-surgical or systemic therapy.

In the case studies presented, PET-CT proved instrumental in identifying:

- Non-iodine avid metastases,
- Differentiating benign from malignant nodules,
- Detecting incidental cancers early,
- Guiding further management and surgical planning.

These findings emphasize the complementary role of PET-CT to conventional diagnostic tools such as ultrasonography, fine-needle aspiration cytology (FNAC), and radioactive iodine scans.

**Limitations**

Despite its advantages, PET-CT has several limitations that must be considered:

1. Limited Sensitivity for Small Lesions: FDG PET may not detect small tumors Or micro metastases (<5 mm), especially in early-stage disease.

2. **False** Positives: Inflammatory or benign hyper metabolic lesions can also take up FDG, leading to potential misdiagnosis.

3. Cost and Accessibility: PET-CT is expensive and not always available in all healthcare settings, limiting its routine use.

4. **Radiation Exposure:** Although generally acceptable, combined PET-CT involves high radiation doses compared to stand alone imaging.

5. Limited Value in Well-Differentiated Tumors**:** Many differentiated thyroid Cancers are slow-growing and may not show high FDG uptake leading to false Negatives.

6. **Lack of Standardization:** Variability in FDG uptake (SUV values), protocols,

**Lack of standardization:** Variability in FDG uptake (SUV values), protocols, and interpretation may lead to inconsistent diagnostic outcomes.

**Comparative** Insights

| **Modality** | **Advantage** | **Limitation** |
|---|---|---|
| Ultrasound (USG) | High solution neck imaging, cost-effective, widely available | Operator-dependent, limited to cervical region |
| Radiation Scan (I-131) | Good for well-differentiated, Iodine-avid cancer | Ineffective in non-avid or poorly differentiated tumors |
| CT/MRI | Excellent anatomical detail | Limited metabolic information may miss functional recurrence |
| PET/CT | Functional anatomical data, detects recurrence/metastasis | High cost, false positives, not Useful for low-trade. iodine-avid tumors |

PET-CT thus fills a crucial gap, particularly for:
Patients with negative iodine scans bllt }aDSitive biochemical markers
Aggressive or recurrent thyroid cancers
Distant metastasis evaluation
It is not a replacement but rather a supplemental tool to traditional modalities, enhancing
Diagnostic precision and enabling personalized patient management.

**Conclusion**

PET-CT has become a cornerstone in selected thyroid cancer cases. By identifying disease not seen with other imagine and building treatment decisions, ii plays a critical role especially when conventional imaging yields inconclusive results. However, its use must be individualized; balancing clinical benefit against cost, availability, and patient-specific factors. The integration of PET with CT imaging has significantly enhanced the diagnostic accuracy and clinical management of thyroid cancer, especially in complex and advanced cases. While traditional modalities like ultrasound and radioactive iodine scans remain the first-line tools, PET-CT has proven to be a Powerful adjunct, particularly in: Detecting recurrent or residual disease when iodine scans are negative, Staging poorly differentiated and aggressive thyroid cancers, Identifying distant metastases with greater precision, Monitoring therapy response and guiding surgical decisions. The combination of metabolic and anatomical information provided by PET-CT differs a more comprehensive assessment than either modality alone. Through the analysis of multiple case studies. is evident that PET-CT contributes meaningfully to early diagnosis, accurate staging, and appropriate treatment planning, ultimately improving patient outcomes. However, due consideration must be given to its limitations such as high cost, limited sensitivity in small or well-differentiated tumors, and potential for false positives. Thus, its use should be tailored to individual clinical scenarios where its benefits outweigh the drawbacks. In conclusion, PET- CT stands out as a valuable imaging modality in the multidisciplinary approach to thyroid cancer diagnosis and management.With advancing technology and wider available likely to play an even more significant role in the future of oncologic imaging.

**Conflict of interest**

All the authors read the manuscript and approved for the submission, so no authors have no conflict of interest.

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**Author's contribution**

**I. Ado:** Data Curation, Data analysis, Manuscript Draft writing, editing, and review. **P.H.:** Supervision, Data analysis, manuscript editing and review, **A.H**:Author, Data analysis, manuscript editing and review.

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