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ORIGINAL RESEARCH

# Association of SUVmax with Malignancy in Focal FDG-Avid Thyroid Incidentalomas

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**ABSTRACT**

Thyroid incidentalomas (TIs) detected on 18F-fluorodeoxyglucose positron emission tomography/computed tomography (FDG PET/CT) are associated with an increased risk of malignancy, particularly in the presence of focal FDG uptake. While quantitative PET/CT parameters, such as the maximum standardized uptake value (SUVmax), have been extensively studied, current management guidelines primarily rely on nodule size and ultrasonographic features. This study aimed to evaluate whether PET/CT-derived radiological parameters provide additional information for malignancy in FDG-avid TIs. This retrospective single-center study included patients with focal FDG-avid thyroid incidentalomas detected on PET/CT who underwent ultrasonographic evaluation and cytological and/or histopathological confirmation. Demographic characteristics, metabolic parameters derived from PET/CT scans, ultrasonographic findings and anatomical localization were documented. Benign and malignant lesions were compared. Receiver operating characteristic (ROC) analysis was conducted to determine the optimal SUVmax cut-off value and logistic regression analyses were employed to identify variables independently associated with malignancy. A total of 53 patients were included, with 13 (24.5%) having malignant thyroid lesions. Malignant nodules demonstrated significantly higher SUVmax values than benign nodules (p=0.008). ROC analysis established a SUVmax cut-off value of 5.8 for discrimination between benign and malignant nodules (AUC: 0.748). Isthmus localization also remained significant in multivariate analysis (p=0.037). No other morphologic or ultrasonographic parameters were significant. In cases of focal FDG-avid TIs, an SUVmax value of ≥5.8 is associated with an increased risk of malignancy and may provide complementary information in risk stratification. However, SUVmax should be interpreted alongside clinical and ultrasonographic findings, not as a standalone decision-making tool.

**Keywords: Thyroid incidentaloma. FDG PET/CT. SUVmax. Risk of thyroid malignancy. Thyroid fine-needle aspiration biopsy.**

**Fokal FDG-Tutulumlu Tiroid İnsidentalomalarında SUVmax'ın Malignite ile İlişkisi**

**ÖZET**

18F-Florodeoksiglukoz pozitron emisyon tomografisi/bilgisayarlı tomografi (FDG PET/BT) ile saptanan tiroid insidentalomaları (Tİ'ler), özellikle fokal FDG tutulumu varlığında, artmış malignite riski ile ilişkilidir. Maksimum standartlaştırılmış tutulum değeri (SUVmax) gibi kantitatif PET/BT parametreleri kapsamlı şekilde incelenmiş olsa da, mevcut yönetim kılavuzları esas olarak nodül boyutu ve ultrasonografik özelliklere dayanmaktadır. Bu çalışmanın amacı, FDG tutulumu olan Tİ'lerde PET/BT'den elde edilen radyolojik parametrelerin malignite açısından ek bilgi sağlayıp sağlamadığını değerlendirmektir. Bu retrospektif, tek merkezli çalışmaya PET/BT'de fokal FDG tutulumu olan Tİ saptanan, ultrasonografik değerlendirme ve sitolojik ve/veya histopatolojik doğrulama yapılan hastalar dahil edilmiştir. Demografik özellikler, PET/BT görüntülerinden elde edilen metabolik parametreler, ultrasonografik bulgular ve anatomik lokalizasyon kaydedilmiştir. Benign ve malign lezyonlar karşılaştırılmıştır. Optimal SUVmax cut-off değerini belirlemek için ROC analizi yapılmış ve malignite ile bağımsız olarak ilişkili değişkenleri belirlemek amacıyla lojistik regresyon analizleri kullanılmıştır. Toplam 53 hasta dahil edilmiş olup, bunların 13'ünde (%24,5) malign tiroid lezyonu saptanmıştır. Malign nodüller, benign nodüllere kıyasla anlamlı derecede daha yüksek SUVmax değerleri göstermiştir (p=0,008). ROC analizi, benign ve malign nodülleri ayırt etmek için 5.8'lik bir SUVmax cut-off değeri belirlemiştir (AUC: 0,748). İstmus yerleşimi de çok değişkenli analizde anlamlılığını korumuştur (p=0,037). Diğer morfolojik veya ultrasonografik parametreler anlamlı bulunmamıştır. Fokal FDG tutulumu olan Tİ olgularında, SUVmax ≥5.8 değeri artmış malignite riski ile ilişkilidir ve risk sınıflandırmasında tamamlayıcı bilgi sağlayabilir. Ancak SUVmax, tek başına karar verme aracı olarak değil, klinik ve ultrasonografik bulgularla birlikte yorumlanmalıdır.

**Anahtar Kelimeler: Tiroid insidentaloma. FDG PET/CT. SUVmax. Tiroid malignite riski. Tiroid ince iğne aspirasyon biyopsisi.**

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18F-fluorodeoxyglucose (18F-FDG) positron emission tomography/computed tomography (PET/CT) is a commonly used imaging technique for staging and evaluating treatment response in various types of cancer[1]. With the increasing use of PET/CT scans, FDG-avid lesions are being more frequently discovered incidentally during examinations conducted for non-thyroid related reasons. Thyroid lesions found among these incidental discoveries are referred to as thyroid incidentalomas (TIs)[2]. The incidence of TIs on FDG PET/CT examinations is reported to range from 1% to 4% in the literature[3–6].

On PET/CT scans, FDG uptake in the thyroid gland may appear in diffuse, focal or heterogeneous patterns. Diffuse FDG uptake is most commonly associated with thyroiditis, Graves' disease and other benign inflammatory thyroid conditions, generally indicating a low risk of malignancy[6–8]. In contrast, TIs with focal FDG uptake have a significantly higher malignancy risk with literature reporting malignancy rates between 20% and 45%[5,6,9,10].

The role of PET/CT-derived imaging parameters in predicting the malignant potential of TIs has been evaluated in various studies, with the maximum standardized uptake value (SUVmax) being one of the most commonly investigated semi-quantitative parameters[11]. However, the guidelines of the American Thyroid Association (ATA) primarily base management decisions on the size of nodules and their ultrasonographic features, rather than on quantitative measurements derived from PET/CT scans. According to the ATA recommendations, FDG-avid thyroid nodules should initially be confirmed through ultrasonography. For lesions measuring 1 cm or larger, a fine-needle aspiration biopsy (FNAB) is recommended. In contrast, smaller nodules that do not meet biopsy criteria should be managed with a follow-up strategy similar to the approach taken for high-risk thyroid nodules[12].

Therefore, this study aimed to determine whether SUVmax and other PET/CT-derived radiological parameters offer additional information regarding the association with malignancy beyond the size- and ultrasound-based approach recommended by current guidelines in thyroid incidentalomas exhibiting FDG uptake.

## Materials and Methods

### *Study Population and Patient Selection*

A retrospective analysis was conducted on patients who underwent fine-needle aspiration biopsy (FNAB) for thyroid nodules at the Oncology and Endocrinology clinics of Uludağ University between January 2015 and January 2025. All patients had a known oncological diagnosis and were under routine follow-up for their condition.

Only patients with focal FDG uptake in the thyroid gland on PET/CT scans were included in the study. The primary objective was to assess the relationship between FDG avidity and the risk of malignancy. Patients who did not have thyroid FDG uptake were excluded.

FNAB procedures performed based on ultrasonographic findings in patients who did not have a PET/CT examination within the preceding three months were excluded, as FDG uptake status could not be reliably assessed in these cases. Other exclusion criteria included diffuse or heterogeneous thyroid FDG uptake, known thyroid malignancy, prior thyroid surgery and indeterminate cytological results without further diagnostic confirmation. In patients with multiple thyroid nodules, only the index nodule that underwent FNAB and demonstrated focal FDG uptake on PET/CT was included in the analysis. All analyses were performed on a per-patient basis.

All included patients had documented focal FDG uptake on PET/CT and concurrent thyroid ultrasonography findings, with established clinical indications for FNAB in their medical records. FNAB samples were evaluated cytologically and initially classified as benign, malignant or indeterminate. Indeterminate cytological results were excluded only if no further diagnostic confirmation was available. Patients who underwent repeat biopsy or surgical resection and achieved a definitive final diagnosis were included in the final analysis. In patients who underwent surgical resection, the final diagnosis was established through histopathological evaluation.

The patient selection process is summarized in Figure 1.

### *F-18 FDG PET/CT Imaging*

Patients were instructed to fast for at least 4–6 hours before the procedure. Only those with blood glucose levels below 200 mg/dL received an intravenous injection of F-18 FDG at a dose of 0.12–0.14 mCi/kg (4.4–5.5 MBq/kg). Approximately 60 minutes after administration, image acquisition was performed using a Biograph 6 LSO PET/CT scanner (Siemens Medical Systems, Erlangen, Germany), covering the area from the skull base to the proximal femurs. For

anatomical localization and attenuation correction, CT scans were obtained at a slice thickness of 3.0 mm with 110 mA and 120 kV settings. Standard whole-body PET imaging was then performed, with a scanning duration of approximately 3 minutes per bed position. Fused PET/CT images were subsequently reconstructed using the vendor-provided reconstruction algorithms routinely applied in accordance with institutional protocols.

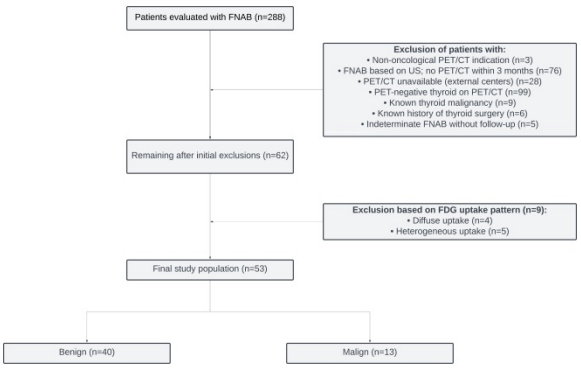


***Figure 1.***
*Flowchart showing the patient selection process. Patients were included based on focal FDG uptake observed on PET/CT and the availability of ultrasonographic, cytological and/or histopathological data. Reasons for exclusion are also indicated.*

*Image Interpretation*

All PET/CT images were reviewed retrospectively by two experienced nuclear medicine physicians who were unaware of the histopathological outcomes and clinical diagnoses of the patients. Each physician interpreted the images independently. In cases where their interpretations differed, they reached a consensus by re-evaluating the images together, alongside the original official PET/CT reports. Ultrasonographic features, such as echogenicity, margin characteristics, the presence of microcalcifications and a multinodular structure were extracted from the available reports.

*The maximum Standardized Uptake Value (SUVmax) Measurement*

SUV is defined as the concentration of tissue radioactivity (in kBq/mL) divided by the injected dose (in kBq), and it is normalized to the patient's body weight (in grams). For each lesion, a spherical volume of interest (VOI) was manually outlined around the area of focal thyroid FDG uptake on the PET images with anatomical correlation from the CT component to ensure accurate localization. The SUVmax was then calculated as the highest voxel value within the VOI.

*Statistical Analysis*

Data were analyzed using SPSS version 29.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation or median values, as appropriate, while categorical variables were presented as frequencies and percentages. Comparisons between benign and malignant TIs were conducted using the independent samples t-test or Mann-Whitney U test for continuous variables. The chi-square test was utilized for categorical variables, as appropriate.

Receiver operating characteristic (ROC) curve analysis was used to evaluate the diagnostic performance of SUVmax in predicting thyroid malignancy and the optimal cut-off value was determined using the Youden index. Univariate logistic regression analysis was performed to identify variables associated with thyroid malignancy. Variables with a p-value $< 0.05$ in univariate analysis were included in the multivariate logistic regression model. A p-value $<0.05$ was considered statistically significant.

## Results

A total of 53 patients with TIs detected on PET/CT were included in the study. The mean age of the study population was 63±10 years and 60.4% of the patients were female. The median long-axis diameter of the thyroid nodules was 16 mm while the median short-axis diameter was 12 mm. Additionally, 17% of the nodules were located in the isthmus. Hypoechoic nodules accounted for 67.9% of the cases and 45.3% of the patients had a multinodular thyroid gland. Irregular margins and microcalcifications were found in 15.1% and 13.2% of the nodules, respectively. The median SUVmax value was 5.3, as summarized in Table I.

The distribution of primary malignancies in the study population is shown in Table II. The most common primary malignancies were breast cancer (24.5%) and lung cancer (18.8%), followed by colorectal cancer and malignant melanoma. Among the 53 TIs, 24.5% were found to be malignant. Two cases of malignancy were diagnosed after surgical resection, following indeterminate results from FNAB. The histopathological analysis revealed that papillary thyroid carcinoma was the most common subtype, accounting for 61.5% of the malignant cases. Follicular thyroid carcinoma represented 7.7% of the malignant cases. Additionally, 23.1% of the malignant cases were due to metastatic disease that originated from the patients' primary cancers. One malignant case was diagnosed as non-Hodgkin lymphoma involving the thyroid gland.

**Table I.** Baseline Characteristics of Patients with Thyroid Incidentalomas Detected on PET/CT (n=53)

| Parameters | n |
|---|---|
| **Age, *(mean ± SD)*** | 63 ± *10* |
| **Sex,** | |
| Male, *(%)* | 21 39.6 |
| Female, *(%)* | 32 60.4 |
| **Nodule size, *(median)*** | |
| *Long axis, (mm)* | 16 (8-50) |
| *Short axis, (mm)* | 12 (5-45) |
| *Area, (mm²)* | 195 (40-2205) |
| **Lobe** | |
| *Right, (%)* | 19 35.8 |
| *Left, (%)* | 25 47.2 |
| *Isthmus, (%)* | 9 17 |
| **Echogenicity** | |
| *Non-hypoechoic, (%)* | 17 32.1 |
| *Hypoechoic, (%)* | 36 67.9 |
| **Multinodular thyroid gland** | |
| *No, (%)* | 29 54.7 |
| *Yes, (%)* | 24 45.3 |
| **Margin pattern** | |
| *Regular, (%)* | 45 84.9 |
| *Irregular, (%)* | 8 15.1 |
| **Microcalcification** | |
| *No, (%)* | 46 86.8 |
| *Yes, (%)* | 7 13.2 |
| **Area/SUVmax, *(median)* *(mm²)*** | 35.3 (9.3-358.4) |
| **SUVmax, *(median)*** | 5.3 (2.4-20.7) |

SD: Standard deviation, SUV: Standardized uptake value

**Table II.** The distribution of primary cancers in the study population (n=53)

| Cancer Type | n | % |
|---|---|---|
| *Breast cancer* | 13 | 24.5 |
| *Colorectal cancer* | 6 | 11.3 |
| *Endometrial cancer* | 4 | 7.5 |
| *Gastric cancer* | 3 | 5.7 |
| *Head and neck cancer* | 2 | 3.8 |
| *Liposarcoma* | 1 | 1.9 |
| *Lung cancer* | 10 | 18.8 |
| *Malignant melanoma* | 6 | 11.3 |
| *Mesothelioma* | 1 | 1.9 |
| *Pancreatic cancer* | 3 | 5.7 |
| *Renal cell carcinoma* | 3 | 5.7 |
| *Thymoma* | 1 | 1.9 |

Table III provides a comparison between benign and malignant TIs. There were no significant differences between the benign and malignant groups regarding age, the size of the nodule (measured by long axis, short axis, or area), the status of the multinodular thyroid gland, the presence of microcalcifications or the area/SUVmax ratio. However, nodules located in the isthmus were found to be significantly more common in malignant incidentalomas compared to benign ones with rates of 38.5% for malignant nodules and 10% for benign nodules (p=0.031). Furthermore, the median SUVmax was significantly higher in malignant nodules (7.0) than in benign nodules (4.7) with a p-value of 0.008.

ROC curve analysis showed that SUVmax has moderate discriminative ability for malignancy risk assessment. The area under the curve was found to be 0.748 (95% CI: 0.613–0.883, p<0.001), as illustrated in Figure 2. The optimal cut-off value for SUVmax, determined using the Youden index, was found to be 5.8. This cut-off yielded a sensitivity of 76.9% and a specificity of 65.0%, a positive predictive value (PPV) of 41.7% and a negative predictive value (NPV) of 89.7%.

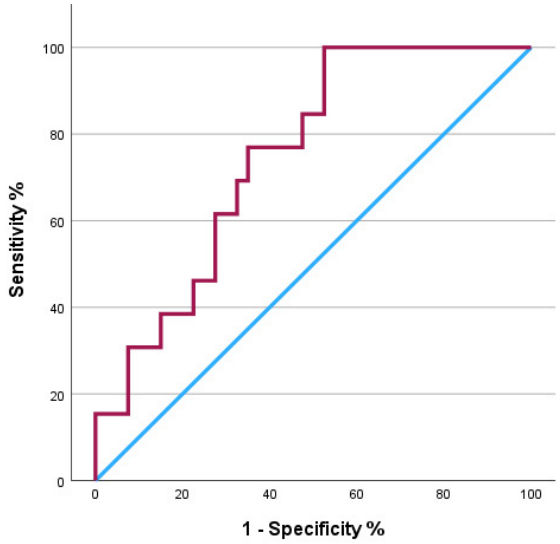


***Figure 2.***
*Receiver operating characteristic (ROC) curve analysis of SUVmax for discrimination between benign and malignant focal FDG-avid thyroid incidentalomas. The area under the curve (AUC) was 0.748 and the optimal cut-off value was 5.8.*

A summary of the univariate and multivariate logistic regression analyses assessing factors associated with thyroid malignancy is presented in Table IV. In the univariate analysis, isthmus localization was significantly associated with thyroid malignancy with an odds ratio (OR) of 5.63 (p=0.026). Additionally, SUVmax of 5.8 or greater was also significantly associated (OR=6.19, p=0.013). Variables with a p-value of less than 0.05 from the univariate analysis were included in the multivariate model. In the multivariate analysis, both isthmus localization (OR=6.09, p=0.037) and SUVmax≥5.8 (OR=6.54, p=0.017) remained significant.

**Table III.** Comparison of Benign and Malignant Thyroid Incidentalomas Detected on PET/CT

| Parameters | Benign (n=40) | Malignant (n=13) | p-value |
|---|---|---|---|
| **Age, *(mean ± SD)*** | 63.8 *( ± 10.3)* | 60.8 *(± 9.3)* | 0.354[a] |
| **Sex** | | | |
| Male, *(%)* | 13 (32.5) | 8 (61.5) | 0.063[b] |
| Female, *(%)* | 27 (67.5) | 5 (38.5) | |
| **Nodule size, *(median)*** | | | |
| *Long axis, (mm)* | 15 *(8-46)* | 18 *(8-50)* | 0.225[c] |
| *Short axis, (mm)* | 11.5 *(7-45)* | 13 *(5-45)* | 0.401[c] |
| *Area, (mm²)* | 180 *(56-2070)* | 234 *(40-2205)* | 0.311[c] |
| **Lobe** | | | |
| *Isthmus, (%)* | 4 *(10)* | 5 *(38.5)* | **0.031**[b] |
| *Other, (%)* | 36 *(90)* | 8 *(61.5)* | |
| **Echogenicity** | | | |
| *Hypoechoic, (%)* | 30 *(75)* | 6 *(46.2)* | 0.086[b] |
| *Other, (%)* | 10 *(25)* | 7 (53.8) | |
| **Multinodular thyroid gland** | | | |
| No, *(%)* | 21 *(52.5)* | 8 *(61.5)* | 0.570[b] |
| Yes, *(%)* | 19 *(47.5)* | 5 *(38.5)* | |
| **Margin pattern** | | | |
| *Regular, (%)* | 36 *(90)* | 9 *(69.2)* | 0.090[b] |
| *Irregular, (%)* | 4 *(10)* | 4 *(30.8)* | |
| **Microcalcification** | | | |
| *No, (%)* | *36 (90)* | *10 (76.9)* | 0.343[b] |
| *Yes, (%)* | *4 (10)* | *3 (23.1)* | |
| **Area/SUVmax, (median) (mm²)** | 34.7 *(11.6-358.4)* | 39.3 *(9.3-110.1)* | 0.563[c] |
| **SUVmax, *(median)*** | 4.7 (2.4-19) | 7 (4.3-20.7) | **0.008**[c] |

SD: Standard deviation, SUV: Standardized uptake value, a: Independent sample t-test, b: Chi-square test (Pearson or Exact, as Appropriate), c: Mann-Whitney U test

## Discussion and Conclusion

TIs detected by FDG PET/CT scans are becoming increasingly common and can have significant malignant potential, particularly when there is focal FDG uptake. In routine clinical practice, recommendations for the management of FDG-avid TIs primarily rely on nodule size. However, this size-based approach may not always adequately reflect the clinical significance of lesions demonstrating increased metabolic activity, regardless of nodule size, especially in oncological patients. In individuals under follow-up for an oncological malignancy, the detection of marked FDG uptake in the thyroid gland introduces an additional layer of uncertainty in clinical decision-making.

Given the well-established association between increased metabolic activity and malignancy, clinicians are often faced with a challenging dilemma: the need for prompt evaluation to exclude disease recurrence or a synchronous secondary malignancy must be balanced against the risk of unnecessary diagnostic interventions. In this context, evaluating quantitative parameters reflecting metabolic activity—particularly SUVmax—alongside conventional morphological features may provide complementary information for risk stratification in focal FDG-avid TIs.

SUVmax reflects increased glucose metabolism within a lesion but is not a specific marker of

**Table IV.** Analysis of Factors Associated with Thyroid Malignancy Using Univariate and Multivariate Logistic Regression

| | Univariate Analysis | | | | Multivariate Analysis | | | |
|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | | p-value | OR | 95% CI | | p-value |
| | | Lower | Upper | | | Lower | Upper | |
| **Age (Years)** | 0.970 | 0.911 | 1.034 | 0.349 | | | | |
| **Sex, (male vs female [RC] )** | 0.301 | 0.082 | 1.103 | 0.070 | | | | |
| **Long axis, (mm)** | 1.034 | 0.977 | 1.094 | 0.247 | | | | |
| **Short axis, (mm)** | 1.021 | 0.959 | 1.088 | 0.514 | | | | |
| **Area, (mm²)** | 1.001 | 0.999 | 1.002 | 0.355 | | | | |
| **Lobe, (isthmus vs other lobe [RC] )** | 5.625 | 1.228 | 25.762 | **0.026** | 6.086 | 1.113 | 33.283 | **0.037** |
| **Echogenicity, (hypoechoic vs other [RC] )** | 0.286 | 0.078 | 1.053 | 0.060 | | | | |
| **Multinodular thyroid gland, (yes vs no [RC] )** | 0.691 | 0.192 | 2.480 | 0.571 | | | | |
| **Margin pattern, (irregular vs regular [RC] )** | 4.000 | 0.835 | 19.162 | 0.083 | | | | |
| **Microcalcification, (yes vs no [RC] )** | 2.700 | 0.517 | 14.098 | 0.239 | | | | |
| **Area/SUVmax, (mm²)** | 0.995 | 0.981 | 1.009 | 0.453 | | | | |
| **SUVmax, (high vs low [RC] )** | 6.190 | 1.460 | 26.248 | **0.013** | 6.537 | 1.401 | 30.488 | **0.017** |

OR: Odds Ratio, CI: Confidence Interval, RC: Reference Category, SUV: Standardized uptake value

malignancy[1]. Nevertheless, a wide range of reported SUVmax cut-off values has been proposed in the literature[10,11,13,14]. This variability is likely due to methodological differences and patient-related confounding factors, such as concurrent inflammatory processes[6]. In a study conducted by Abdulrezzak et al. involving 214 patients with histopathological confirmation, the optimal SUVmax cut-off value for the overall cohort was identified as 3.5. However, among the 125 patients who exhibited focal FDG uptake, this cut-off value was higher, at 5.8[15]. Similarly, Tuzcu et al. reported an optimal SUVmax cut-off value of 5.5 in a cohort of 131 patients with focal FDG-avid TIs[16]. In another study involving 40 patients with underlying oncological malignancies and concurrent TIs, the median SUVmax value was found to be 5.4[17]. In our study, the median SUVmax value was 5.3, and the ROC curve analysis identified an optimal SUVmax cut-off value of 5.8, demonstrating good discriminatory performance between malignant and benign lesions. These findings align with previously reported data on focal FDG-avid TIs. Additionally, the observed malignancy rate in our cohort (24.5%) is consistent with literature rates for focal TIs. Taken together, these results suggest that SUVmax, when interpreted alongside conventional morphological parameters, may provide complementary information for risk stratification in focal FDG-avid TIs in standard clinical practice. Notably, recent evidence suggests that SUVmax remains a robust and clinically relevant parameter, as even contemporary artificial intelligence–based radiomics approaches have not demonstrated a clear diagnostic advantage over SUVmax alone in the evaluation of focal FDG-avid TIs[18].

In addition to metabolic activity, the anatomical characteristics of thyroid nodules may also play a role in assessing the malignant risk of FDG-avid thyroid lesions. Nodule location within the thyroid gland has been proposed as a potential risk modifier, with several studies indicating differences in malignant potential based on lobar distribution[19,20]. Thyroid nodules originating from the isthmus have garnered increasing attention due to their potentially malignant nature, although the existing data is still limited. The underlying mechanisms are not completely understood. However, some proposed explanations include the unique embryological origin of the isthmus and its relatively small volume of thyroid tissue. This may lower the chances of hyperplastic processes and increase the likelihood that any detected nodule is a neoplastic lesion[20]. Consistent with these observations, our study demonstrated that isthmus localization, together with SUVmax, was independently associated with malignancy in focal FDG-avid TIs.

In contrast, several morphologic and ultrasonographic parameters were not independently associated with malignancy in our cohort. This finding likely indicates that many established ultrasound features mainly contribute to composite risk stratification frameworks, rather than serving as significant independent predictors when assessed in isolation. Parameters related to nodule geometry, internal structure and background thyroid characteristics may lose their discriminatory power when evaluated outside of standardized reporting systems. Accordingly, the lack of independent significance observed for these features should not be interpreted as an absence of clinical relevance. Instead, their value should be considered within integrated risk assessment tools such as the Thyroid Imaging Reporting and Data System (TI-RADS)[21]. Due to the unavailability of TI-RADS classification in the ultrasonographic reports and the retrospective nature of the study, not all necessary parameters could be consistently retrieved. As a result, TI-RADS–based evaluation and direct comparison with current guideline-based risk stratification systems were not possible. Therefore, our findings should be viewed as complementary to established ultrasound-based risk stratification systems, rather than as replacements.

Additionally, the retrospective single-center design, limited sample size, heterogeneous nature of malignant lesions and lack of external validation are important limitations to consider when interpreting our results. In addition, histopathological heterogeneity among malignant lesions, including primary thyroid cancers and secondary involvement, may have influenced SUVmax measurements and diagnostic performance. In particular, the limited number of malignant events may have increased the risk of overfitting in multivariate logistic regression analyses. Therefore, these findings should be regarded as exploratory and hypothesis-generating rather than definitive. Furthermore, the lengthy study period may have led to gradual changes in imaging protocols and clinical practice patterns, which could have introduced additional variability.

In cases of focal FDG-avid TIs, an SUVmax value ≥5.8 is associated with an increased risk of malignancy. Although the relatively high negative predictive value suggests potential utility in excluding malignancy in nodules with lower SUVmax values, SUVmax should be interpreted together with clinical and ultrasonographic findings and should not be used as a standalone decision-making tool.

**Researcher Contribution Statement**

Idea and design: H.O., F.C.H.; Data collection and processing: H.O., E.I.C., S.B.; Analysis and interpretation of data: H.O., F.C.H., A.B.S., S.C., O.O.G.; Writing of significant parts of the article: H.O., F.C.H.; Critical revision of the manuscript: F.C.H., A.B.S., S.B.; Final review and approval of the manuscript: O.O.G., A.B.S.

## SUVmax and Malignancy in Thyroid Incidentalomas

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**Conflict of Interest Statement**
The authors declare that there are no competing interests.

**Ethics Committee Approval Information:**
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## References

1. Boellaard R, Herrmann K, Barrington SF, et al. [18F]FDG PET/CT: EANM procedure guidelines for tumour imaging: version 3.0. *EANM J*. 2025;1(September):100006. doi:10.1016/j.eanmj.2025.100006
2. Yoon DY, Chang SK, Choi CS, et al. The prevalence and significance of incidental thyroid nodules identified on computed tomography. *J Comput Assist Tomogr*. 2008;32(5):810-815. doi:10.1097/RCT.0b013e318157fd38
3. Dondi F, Pasinetti N, Gatta R, Albano D, Giubbini R, Bertagna F. Comparison between Two Different Scanners for the Evaluation of the Role of18F-FDG PET/CT Semiquantitative Parameters and Radiomics Features in the Prediction of Final Diagnosis of Thyroid Incidentalomas. *J Clin Med*. 2022;11(3). doi:10.3390/jcm11030615
4. Signore G, Albano D, Giovanella L, Bertagna F, Treglia G. Evidence-Based Data About Prevalence and Risk of Malignancy of Thyroid Incidentalomas Detected by Different PET Radiopharmaceuticals. *Curr Radiopharm*. 2020;13(2):89-93. doi:10.2174/1874471012666191212115732
5. Soelberg KK, Bonnema SJ, Brix TH, Hegedüs L. Risk of malignancy in thyroid incidentalomas detected by 18F-fluorodeoxyglucose positron emission tomography: A systematic review. *Thyroid*. 2012;22(9):918-925. doi:10.1089/thy.2012.0005
6. Bertagna F, Treglia G, Piccardo A, Giubbini R. Diagnostic and clinical significance of F-18-FDG-PET/CT thyroid incidentalomas. *J Clin Endocrinol Metab*. 2012;97(11):3866-3875. doi:10.1210/jc.2012-2390
7. Larg M iulia. diagnostics Evaluation of Malignancy Risk in 18F-FDG PET / CT Thyroid Incidentalomas. 2019;18:1-9.
8. Kim YH, Chang Y, Kim Y, et al. Diffusely increased 18f-fdg uptake in the thyroid gland and risk of thyroid dysfunction: A cohort study. *J Clin Med*. 2019;8(4):1-11. doi:10.3390/jcm8040443
9. de Leijer JF, Metman MJH, van der Hoorn A, et al. Focal Thyroid Incidentalomas on 18F-FDG PET/CT: A Systematic Review and Meta-Analysis on Prevalence, Risk of Malignancy and Inconclusive Fine Needle Aspiration. *Front Endocrinol (Lausanne)*. 2021;12(October):1-15. doi:10.3389/fendo.2021.723394
10. Kostek M. Deciding on Fine Needle Aspiration Biopsy in Thyroid Incidentalomas in FDG-PET/CT: Should Ultrasonographic Evaluation or FDG Uptake Be in the Foreground? *SiSli Etfal Hastan Tip Bul / Med Bull Sisli Hosp*. 2025;59(1):20-27. doi:10.14744/semb.2025.49140
11. Familiar C, Merino S, Valhondo R, et al. Prevalence and clinical significance in our setting of incidental uptake in the thyroid gland found on 18F-fluordeoxyglucose positron emission tomography-computed tomography (PET-CT). *Endocrinol Diabetes y Nutr (English ed)*. 2023;70(3):171-178. doi:10.1016/j.endien.2023.03.001
12. Haugen BR, Alexander EK, Bible KC, et al. 2015 American Thyroid Association Management Guidelines for Adult Patients with Thyroid Nodules and Differentiated Thyroid Cancer: The American Thyroid Association Guidelines Task Force on Thyroid Nodules and Differentiated Thyroid Cancer. *Thyroid*. 2016;26(1):1-133. doi:10.1089/thy.2015.0020
13. Şencan Eren M, Özdoğan Ö, Gedık A, et al. The incidence of 18F-FDG PET/CT thyroid incidentalomas and the prevalence of malignancy: A prospective study. *Turkish J Med Sci*. 2016;46(3):840-847. doi:10.3906/sag-1503-26
14. Lee H, Chung YS, Lee JH, Lee KY, Hwang KH. Characterization of focal hypermetabolic thyroid incidentaloma: An analysis with F-18 fluorodeoxyglucose positron emission tomography/computed tomography parameters. *World J Clin Cases*. 2022;10(1):155-165. doi:10.12998/wjcc.v10.i1.155
15. Abdulrezzak U, Temizer E, Tutus A. The importance of FDG avidity in incidental thyroid nodules on FDG PET/CT. *Clin Imaging*. 2025;128(42):110626. doi:10.1016/j.clinimag.2025.110626
16. Tuzcu ŞA, Çetin IE, Çetinkaya E, Güzel F, Geneş D, İbiloğlu İ. Comparison of incidentally detected focal FDG uptake in the thyroid gland on PET/CT with fine needle aspiration biopsy results. *Saudi Med J*. 2025;46(8):913-918. doi:10.15537/smj.2025.46.8.20241077
17. Oven BB, Kilicoglu ZG, Bilici A, et al. The relationship between positron emission tomography-computed tomography imaging and histopathological features of thyroid incidentalomas detected during follow-up for primary malignancy. *J Cancer Res Ther*. 2019;15(3):589-595. doi:10.4103/jcrt.JCRT_889_16
18. Ślusarz K, Buchwald M, Szczeszek A, et al. AI may help to predict thyroid nodule malignancy based on radiomics features from [18F]FDG PET/CT. *EJNMMI Res*. 2025;15(1). doi:10.1186/s13550-025-01228-4
19. Hu JF, Xu J, Gao LP, et al. The effect of thyroid nodule location in ultrasound on the diagnosis of papillary thyroid carcinoma. *Discov Oncol*. 2025;16(1):1722. doi:10.1007/s12672-025-03428-9
20. Pastorello R, Valerio E, Lobo A, Maia A, Saieg M. Do thyroid nodules that arise in the isthmus have a higher risk of malignancy? *Cancer Cytopathol*. 2020;128(8):520-522. doi:10.1002/cncy.22260
21. Tessler FN, Middleton WD, Grant EG, et al. ACR Thyroid Imaging, Reporting and Data System (TI-RADS): White Paper of the ACR TI-RADS Committee. *J Am Coll Radiol*. 2017;14(5):587-595. doi:10.1016/j.jacr.2017.01.046