



# Usefulness of SPECT/CT Imaging in the Management of Patients with Differentiated Thyroid Carcinoma

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## ABSTRACT

**Objective:** Whole-body I-131 scanning (WBS) is a standard method in the evaluation of patients with differentiated thyroid carcinoma (DTC). However, it has some limitations in terms of distinguishing between physiological and pathological tracer uptake and in defining the exact anatomical location of pathological foci. The purpose of our study was to determine the additional diagnostic value of SPECT/CT imaging in patients with DTC.

**Materials and Methods:** A total of 142 patients, each with a history of previous total thyroidectomy and who had undergone diagnostic or post-therapeutic WB imaging, were included in this retrospective study. The distinction between physiological and pathological uptake could not be clearly established and/or the localization of pathological uptake could not be clearly defined on the WBS, both of which were considered inconclusive findings. Subsequently, the regional SPECT/CT images of these patients were evaluated.

**Results:** The number of pathological foci detected by WBS and SPECT/CT was 64 and 59, respectively. The exact anatomical localization was determined in 85.9% of the lesions with SPECT/CT. Benign accumulations (inflammatory/physiological) were determined in 12.5% of inconclusive foci. In 14.1% of WBS-detected foci, no significant tracer uptake was observed on the SPECT/CT images. Four additional foci were detected on SPECT/CT (3 thyroid remnants, 1 bone remnant).

**Conclusion:** SPECT/CT improves the specificity of I-131 scanning and contributes to the management of DTC patients.

**Keywords:** Differentiated thyroid carcinoma, 131-I, SPECT

## INTRODUCTION

Differentiated thyroid carcinoma (DTC) is the most widely encountered malignant endocrine disease and is generally associated with a good prognosis, depending on prognostic indicators, such as stage and age at diagnosis, histological subtype, and sex (1, 2). The primary treatment modality is surgery; recent recommendations include only lobectomy, which is limited to papillary microcarcinomas without any additional risk factors (3). In patients with moderate to high risk, the procedure consists of destroying the remnant thyroid tissues and the locoregional or distant foci with radioiodine. The American Thyroid Association Practice Guidelines for Thyroid Cancer Management recommended 131-I ablation in the following situations: grossly invasive cancer, primary tumors measuring >4 cm, presence of distant metastasis, 1–4 cm large tumors limited to the thyroid, documented node metastasis, or other high-risk features (4).

Radionuclide planar whole-body scanning (WBS) with 131-I or 123-I is a commonly performed treatment modality with high sensitivity seen during the follow-up of patients with DTC (5, 6). However, low image resolution, physiological uptake sites being confused with pathological foci, and difficulties in determining the exact anatomical location of foci limit the diagnostic capacity of this technique. SPECT/CT provides morphological and functional data and has been reported to increase the sensitivity and specificity of 131-I WBS in patients with DTC (7). In our study, we retrospectively evaluated the additional diagnostic value of SPECT/CT in patients with DTC.

## MATERIALS and METHODS

A total of 142 patients (27 M, 115 F) with a history of previous total thyroidectomy were evaluated retrospectively (20–79 years, mean age: 48±13). The study was approved by the ethical committee of Ondokuz Mayıs University. The histopathological examination revealed a papillary carcinoma in 92 patients, follicular carcinoma in 43 patients, and mixed-type carcinoma (papillary and follicular) in 7 patients. A total of 21 patients were re-operated for residual tissue or relapse. Of the 142 patients, 47 underwent diagnostic WB imaging after the oral administration of 185 MBq 131-I (all patients had previously been treated with radioiodine). The remaining 95 patients underwent post-therapeutic WB imaging 6-7 days after the oral administration of 2775-7400 MBq 131-I. A dou-

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**Table 1.** Number of inconclusive foci detected during whole-body scanning and number of foci detected on SPECT/CT

	Neck	Thorax	Abdomen	Extremity	Total
WBS	35	19	9	1	64
SPECT/CT	33	20	5	1	59

WBS: Whole Body Scanning

ble-head gamma camera and high energy collimators were used for radionuclide imaging. The table speed was maintained at 5 cm/minute for WB imaging. Additional spot images were acquired for 10 minutes. The SPECT parameters were: 128×128 matrix, 3° angular step, and 40 seconds per frame. Immediately hereafter, a CT scan of the same region was obtained. Tracer uptake in salivary glands, gastrointestinal system, and bladder was considered physiological on planar images. The distinction of physiological and pathological uptake could not be clearly done and/or the localization of pathological uptake could not be clearly defined on the WBS, both of which were considered inconclusive findings. Subsequently, regional SPECT/CT imaging was performed. In all patients, serum thyroid stimulating hormone (TSH) levels were measured after at least 4 weeks of thyroid hormone withdrawal. At the time of imaging, all patients presented with at least 50 µU/mL of TSH levels.

## RESULTS

In 47 of 142 patients, the WBS-detected 64 cases of inconclusive tracer uptake (35 foci were present in the cervical region, 19 foci in the thoracic region, 9 foci in the abdomen, and 1 focus in the upper extremity), after which the patients underwent regional SPECT/CT imaging. The total number of pathological foci detected by SPECT/CT was 59, of which 33 were located in the

cervical region, 20 foci in the thoracic region, 5 foci in the abdomen, and 1 focus in the upper extremity. Of the 33 cervical foci, 24 were compatible with the thyroid tissue remnants, 5 with lymph nodes, 1 with dental structures, 1 with nasal soft tissue, and 2 with salivary activity. Of the 20 foci detected at thoracic region, 7 were localized in the lung, 5 in the mediastinal lymph nodes, 6 in the bone structures, and 2 in the breast tissue. There were 2 foci in the pelvic soft tissue and 1 focus in the upper extremity bone structure. The number of pathologic foci detected on WBS and SPECT/CT images are shown in Tables 1 and 2.

Of the 35 inconclusive cervical foci on the WBS, 5 foci were not detected on SPECT/CT. SPECT/CT images revealed residual tissue in 21 foci. Five were interpreted as lymph nodes, 2 were identified as inflammatory accumulations located at dental and nasal structures, and 2 foci were located at esophagus and considered to be a part of physiological salivary activity. SPECT/CT detected 3 additional low-intensity thyroid remnant foci.

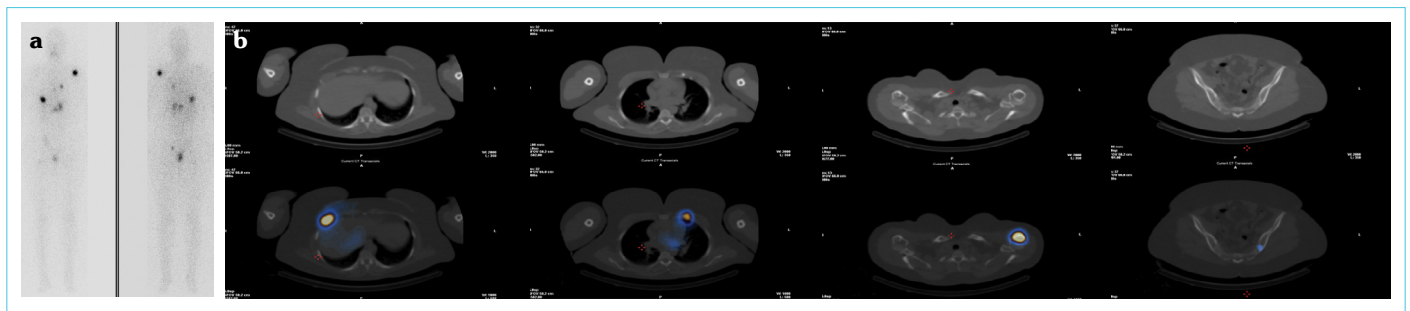
In 19 thoracic foci on WBS, bone and soft tissue could not be safely differentiated. On SPECT/CT images, these were described as: 5 mediastinal lymph nodes, 5 bone lesions, 7 lung lesions, and 2 breast lesions. SPECT/CT detected 1 additional small-sized radiiodine accumulating lesion in the bone.

In the abdominal and pelvic areas, a total of 9 inconclusive foci were detected on the WBS. SPECT/CT images were revealed with intestinal activity in 2 foci and reactive/inflammatory findings associated with IM injections in 2 foci. One focus was located on the pelvic bone. Four foci were no more seen by SPECT/CT. One upper extremity uptake was located at the bone on SPECT/CT.

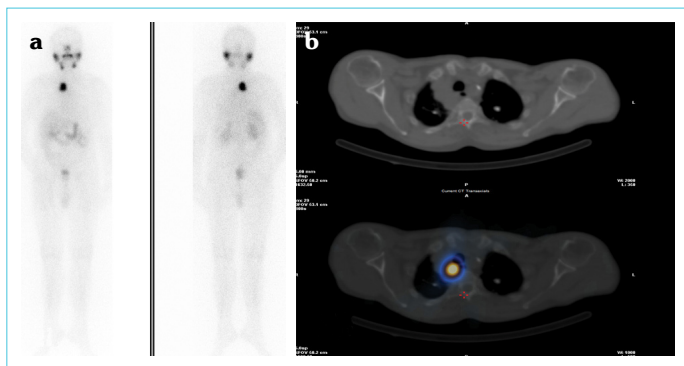
Overall, SPECT/CT determined the exact anatomical localization in 55/64 lesions (85.9%) that were described as inconclusive on WBS. Figure 1 and 2 represent the I-131 WBS and SPECT/CT images of two patients. WBS showed inconclusive tracer ac-

**Table 2.** Number of detected foci on SPECT/CT imaging according to the location

Neck		Thorax				Abdomen			Extremity	Total		
Thyroid remnant	Lymph node	Nasal/Dental	Esophagus	Lung	Mediastinal lymph node	Bone	Breast tissue	Pelvic soft tissue	Intestine	Bone		
24	5	2	2	7	5	6	2	2	2	1	1	59



**Figure 1.** A 46-year-old female underwent total thyroidectomy to remove a follicular thyroid carcinoma (TSH: 100 µIU/mL and Tg: >300 ng/mL). A I-131 wholebody scan showed I-131 accumulation in the left shoulder, thoracic region, and left posterior pelvic area (a). On SPECT/CT images, thoracic accumulations were localized in lytic lesions containing a soft tissue component at the anterior portion of the 2<sup>nd</sup> left to 6<sup>th</sup> right ribs and the humeral head. One low intensity focus was present at the posterior portion of the left iliac bone (b)



**Figure 2.** A 75-year-old male underwent total thyroidectomy with papillary thyroid carcinoma (TSH: 100  $\mu$ IU/mL and Tg: 1010 n/mL). In the I-131 wholebody scan (a), I-131 accumulation was observed in the upper thorax to the right side of the medial line. On SPECT/CT images, the accumulation was localized in the high right mediastinal-paratracheal lymph nodes (b)

cumulations in the thoracic and pelvic regions, whereas SPECT/CT determined the location of pathological foci. Benign accumulations (inflammatory/physiological) were determined in 8 out of 64 (12.5%) inconclusive foci (4 cervical and 4 abdomino-pelvic). Nine of 64 (14.1%) foci detected on the WBS (5 cervical and 4 abdominal) could not be redetected with SPECT/CT. Three additional foci with thyroid remnants and 1 additional bone lesion in the thoracic region were observable on SPECT/CT.

## DISCUSSION

Radionuclide WBS with  $^{131}\text{I}$  is known as a standard method with high specificity in the evaluation of patients with DTC, however, it has some limitations in terms of distinguishing between physiological and pathological tracer uptake and in defining the exact anatomical location of the uptake sites. These limitations, along with the possibility of overcoming problems with SPECT/CT have accelerated further investigation on this subject (8–11). SPECT/CT allows the combination of morphological and functional data, which further improves the accuracy of technique. Menges et al. reported the sensitivity of both  $^{131}\text{I}$  SPECT/CT and WBS as 62% in the diagnosis of DTC, whereas the specificity was increased from 78% to 98% with SPECT/CT (12).

The localization of pathological foci is important in therapy management. Computed tomography is probably the most important component of this technique, since it is very difficult to determine the location of pathological foci with WBS or SPECT alone, without using any morphological marker. Spanu et al. mentioned that SPECT/CT showed better performance than WBS during both classification and localization of lesions, and eventually changed the course of therapeutic management in 21.6% of the patients (13). Additional diagnostic value rates of SPECT/CT over planar imaging vary widely in literature and range from 34% to 74% (14–16). According to Barwick et al., this wide variation was associated with the selection of patients. They mentioned that, if SPECT/CT is used routinely for every patient, an incremental diagnostic value might be expected. When SPECT/CT was performed in all patients on the neck and thoracic regions, the reported diagnostic benefit was

34%–42% (14). In our study, 85.9% of the WBS inconclusive foci were localized with SPECT/CT and this rate was higher than what has been reported in the literature. The highest ratio of the same was observed in the cervical region, which was thought to be because the differentiation of residual thyroid tissue and lymph nodes was difficult because of the lack of evaluation of thyroid scintigraphy in the study. Assessment of WBS findings with thyroid scintigraphy will reduce the number of inconclusive cervical results on the WBS.

SPECT/CT contributes to the treatment approach in some patients. In a study including 365 patients, Zilioli and colleagues reported that TNM stage and treatment plan was modified in 13 patients because of exclusion of false positive accumulations with additional SPECT/CT imaging (17). In our study, 12.5% of inconclusive foci on WBS were determined as benign and pathology was ruled out in these patients. In a few patients, an additional focus was detected with SPECT/CT in the cervical and thoracic regions. Thyroid remnant-compatible foci were small-sized and accumulated low radioiodine. The advantage of having higher contrast resolution with SPECT/CT may have resulted in the detection of these foci. A focus in the bone structure of the thoracic region was missed on the WBS because of its location (the lateral costal area) and the low intensity of the scan.

Some studies have highlighted the limitations of SPECT/CT in the evaluation of patients with DTC. In areas that are not well delineated by CT, results may remain equivocal on SPECT/CT findings in 7%–8% of cases (10, 15). Wong et al. reported that, particularly in cases of proven N1 disease, SPECT/CT is of limited value in revealing regional lymph node metastases in the presence of postoperative thyroid remnants (18). Extending the duration of SPECT/CT makes the patient uncomfortable and may cause patient movement. In this case, possible misregistration of SPECT and CT information may lead to false positive or negative results (9). Further, because of extra time required for SPECT/CT, some physiological activities may displace or disappear and become misleading in the interpretation. In our study, 14.1% of WBS-detected foci were no more detectable on SPECT/CT images. For this reason, it is necessary to obtain SPECT/CT as soon as possible after WBS. Considering the patient comfort and the risk of image misregistration, SPECT/CT should be performed in cases with equivocal/inconclusive findings on WBS.

## CONCLUSION

The possibility of overcoming the limitations of  $^{131}\text{I}$  WBS with SPECT/CT increases the routine usage of this modality. In the recent literature, some authors reported high specificity and improved lesion location by SPECT/CT in DTC patients. Despite some minor limitations, the method clearly improves the classification and localization of  $^{131}\text{I}$  accumulation sites in patients with DTC. SPECT/CT has higher specificity than WBS, particularly in distinguishing lymph node metastases from thyroid remnants, lung metastases from mediastinal uptake, or thoracic bone metastases. SPECT/CT is also valuable in detecting additional lesions as compared to conventional planar imaging.

**Ethics Committee Approval:** The study was approved by the ethical committee of Ondokuz Mayıs University (date: 12.04.2019, number: B.30.2.ODM.0.20.08/350).

**Informed Consent:** Written informed consent was obtained from patients who participated in this study.

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