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Original Article

MRI and ultrasonography detection of cervical lymph node metastases in differentiated thyroid carcinoma before reoperation

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Abstract: Objective: The purpose of this study was to compare the diagnostic capabilities of magnetic resonance imaging (MRI) and ultrasonography (US) for cervical lymph nodal metastases in differentiated thyroid carcinoma (DTC) before reoperation. Material and method: From June 2011 to May 2013, preoperative MRI and ultrasound data were collected from differentiated thyroid cancer patients who underwent a reoperation. The following characteristics were assessed: the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of MRI and US. The MRI and ultrasound findings were correlated with the histological diagnosis after reoperation. Results: One hundred and thirty-eight cases were included in the analysis. 88.4% (122/138) of which had evidence of residual thyroid cancer tissue or metastatic nodal involvement at final histology. Lymph nodal metastases were confirmed in the central compartment in 76.42% (81/106) of patients and in lateral compartment in 73.28% (85/116) of patients. The sensitivity, specificity and accuracy of MRI *VS* US for detecting central compartment metastases was 75% VS 41.67% (P=0.04), 90.91% *VS* 100% (P=1) and 80% *VS* 60% (P=0.618), respectively; For detecting lateral compartment metastases was 83.33% *VS* 77.78% (P=1), 25% *VS* 50% (P=0.606) and 65.38% *VS* 69.23% (P=1), respectively. There was statistically significant difference between the sensitivity of MRI and ultrasound for diagnose of central compartment metastases. The MRI features with the greatest correlation with positive lymph nodal metastases were fusion and enhancing lesions. The ultrasound features with the greatest correlation with positive lymph nodal metastases were hypoechoic and microcalcifications. Conclusion: MRI is more sensitive than ultrasonography in detecting central compartment metastases in papillary thyroid carcinoma. There is no significant difference in diagnosis of lateral neck node metastases between MRI and US.

Keywords: Differentiated thyroid cancer (DTC), reoperation, MRI, ultrasonography

Introduction

Thyroid cancer is the most common malignant tumor of the endocrine system. Approximately constitute 1% of all human malignancies; the most frequent type of thyroid malignancy is papillary thyroid carcinoma; papillary thyroid carcinoma (PTC), follicular thyroid carcinoma (FTC) and anaplastic thyroid carcinoma (ATC) are derived from follicular epithelium. Among these PTC and FTC are coined under the term differentiated thyroid cancer (DTC) which comprises 90% of all thyroid cancers. In general the prognosis of DTC is favorable with an initial treatment. Ten-year survival rate for DTC patients is greater than 90 percent [1, 2]. However, 15 percent to 30 percent of DTC patients will develop or present with metastases after primary surgery and postoperative radioactive iodine-131 therapy; two-thirds of these patients present in first decade after surgery, and have a poor prognosis [3, 4]. Thyroid cancer with metastases about present 85% in neck lymph node, 32% in the thyroid bed, and 12% in distant sites. Reoperation as treatment of relapse is valid [5]. However, the incidence of permanent hypoparathyroidism and Unilateral laryngeal nerve injury of reoperation was signifi-

Table 1. The characteristics of positive lymph nodes VS negative lymph nodes detected on MRI

MRI features	Positive lymph node	Negative lymph node	*P* value
Detection rate of lymph node on MRI	78.57%	36.84%	0.004**
Long diameter	12.69±5.99 mm	11.21±1.47 mm	0.057
Short diameter	7.12±3.27 mm	7.14±1.68 mm	0.333
long-diameter≥10 mm	54.76%	26.3%	0.074
Short-diameter≥5 mm	59.52%	36.84%	0.172
l/s ratio*	1.87±0.74	1.62±0.34	0.262
Clustering	19.05%	10.52%	0.646
Fusion	26.19%	0	0.035**
Necrosis or Cystic degeneration	9.52%	0	0.405
Enhancing lesions	80.95%	36.84%	0.002**

*Ratio of long and short-diameter; **p<0.05 was considered to be statistically significant.

cantly higher than initial surgery, up to 0-9.0%, 1%-12%, respectively [6-8]. So it is important to evaluate cervical lymph nodes especially the central compartment lymph nodes by imaging examination such as MRI, ultrasonography before reoperation.

Materials and methods

The medical records of 138 patients with DTC who underwent reoperation in our department from June 2011 to May 2013 were reviewed. Included criteria: (1) Patients had an MRI scan (unenhanced and contrast-enhanced) of neck before reoperation within two months. (2) Patients had a preoperative ultrasound scan of thyroid and neck lymph node. (3) Patients underwent central compartment lymph node dissection and lateral compartment lymph node dissection (therapeutic dissection), specimens from patients underwent bilateral central lymph node dissection were submitted separately for histopathologic examination. (4) Patients had complete pathologic report.

MRI data were collected before reoperation from PACS system of magnetic resonance imaging chamber in union hospital; Then MRI images were reviewed by two experienced radiologists and the following characteristics were assessed: district of lymph nodes, long diameter, short diameter, the long to short-diameter ratio, cluttering, fusion, necrosis or cystic degeneration, enhancing lesions. The findings were correlated with histological outcomes after reoperation.

Ultrasonic data were collected from medical record room in union hospital. Ultrasonic Images were reviewed by two experienced radiologists and the following characteristics were assessed: district of lymph nodes, echo states, blood flow signals, long diameter, short diameter, necrosis, cystic degeneration, thinned medulla and eccentric shift. The finding were correlated with histological outcomes after reoperation.

The MRI results and B ultrasonography results were correlated with the histological diagnosis to analysis. Statistical software SPSS12.0 was Used for statistical analysis. T-test was used for continuous variables. χ^2 test was used for dichotomous variables. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy of each individual characteristics of MRI, ultrasonography were calculated for central and lateral neck lymph nodal metastases respectively; The sensitivity, specificity and accuracy for central and lateral neck lymph nodal metastases of MRI were evaluated and compared with ultrasonography. P<0.05 was considered to be statistically significant.

Results

The diagnostic value of MRI for lymph nodal metastases

The characteristics of positive lymph nodes VS negative lymph nodes detected on MRI: The positive lymph nodes were identified in 52 of the 70 grounds with central lymph node dissection, and in 36 of 52 grounds with lateral neck lymph node dissection. The characteristics of positive lymph nodes detected on MRI compared with the characteristics of negative lymph nodes are shown in **Table 1**.

Table 2. The diagnostic value of MRI for central lymph nodal metastases

MRI features	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
Long-diameter≥10 mm	41.67	100.00	100.00	44.00	60.00
Short-diameter≥5 mm	50.00	90.91	92.31	45.45	62.86
l/s ratio*≤2	58.33	90.91	93.33	50.00	68.57
Clustering	29.17	90.91	87.50	37.04	48.57
Fusion	29.17	100.00	100.00	39.29	51.43
Enhancing lesions	83.33	90.91	95.24	71.43	85.71
Necrosis or cystic degeneration	12.50	100.00	100.00	34.38	40.00
Overall	75.00	90.91	94.74	62.50	80.00

*Ratio of long and short-diameter.

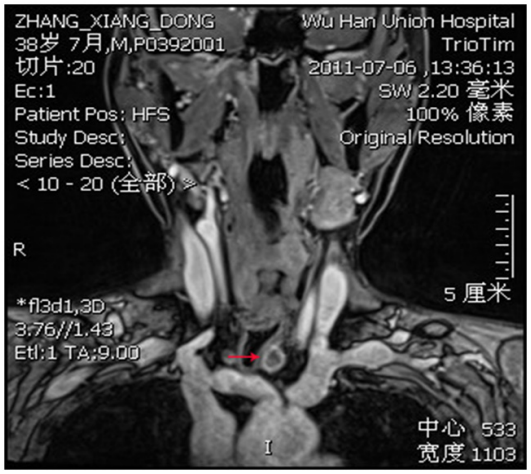

Figure 1. A 39-year-old man presented with a suspicious lymph nodes in central compartment before reoperation. Node size: 15.72*11.12 mm. Surgical pathology showed lymph nodal metastases in left central compartment with 3/3.

The rate of positive lymph nodes (78.57%) was significantly higher than the negative ones (36.84%) (p=0.004) detected on MRI. "Enhancing lesions" is the most sensitive characteristic in detection of positive lymph nodes on MRI. There was a significant difference (p=0.002) between the detection rate of positive lymph nodes group (80.95%) and negative lymph nodes group (36.84%) with "Enhancing lesions" on MRI. In addition, there was a statistically significant difference between the detection rate of positive lymph nodes group and negative lymph nodes group with "fusion" on MRI (p=0.035); There were no statistically significant differences between the detection rate of two groups with Other individual characteristics (long diameter, short diameter, the long to short-diameter ratio, Clustering and necrosis or cystic degeneration) on MRI.

The diagnostic value of MRI for central lymph nodal metastases: The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of MRI for central compartment metastases were 75%, 90.91%, 94.74%, 62.5% and 80%, respectively; As shown in **Table 2**. In contrast to other tests, MRI had higher specificity and positive predictive value for central lymph nodal metastases. Within the individual characteristics of MRI, "Enhancing lesions" had high sensitivity, specificity, and accuracy; "Long-diameter≥10 mm", "Fusion", and "necrosis or cystic degeneration" had a high specificity with 100% and a high positive predictive value with 100% (**Figure 1**).

The diagnostic value of MRI for lateral neck lymph nodal metastases: The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of MRI for lateral neck lymph nodal metastases were 83.33%, 25%, 71.43%, 40%, 65.39%, respectively. As shown in **Table 3**. On the individual characteristics of MRI, "Enhancing lesions" had high sensitivity (77.78%); "fusion", "necrosis or cystic degeneration" had a high specificity with 100% (**Figure 2**).

The diagnostic value of ultrasonography for lymph nodal metastases

The characteristics of positive lymph nodes VS negative lymph nodes detected by ultrasound: The characteristics of positive lymph nodes and negative characteristics detected by ultrasound are shown in **Table 4**.

The rates of positive lymph nodes and negative lymph node detected by ultrasound were 59.52%, 26.31%, respectively; There was no significant difference (p=0.436) between them.

Table 3. Diagnostic value of MRI for detecting lateral neck lymph nodal metastases

MRI features	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
Long-diameter≥10 mm	72.22	37.50	72.22	37.50	61.54
Short-diameter≥5 mm	72.22	25.00	68.42	28.57	57.69
l/s ratio*≤2	61.11	25.00	64.71	22.22	50.00
Clusters	5.56	87.50	50.00	29.17	30.77
fusion	22.22	100.00	100.00	36.36	46.15
Enhancing lesions	77.78	25.00	70.00	33.33	61.54
Necrosis or cystic degeneration	5.56	100.00	100.00	32.00	34.62
Overall	83.33	25.00	71.43	40.00	65.38

*Ratio of long and short-diameter.

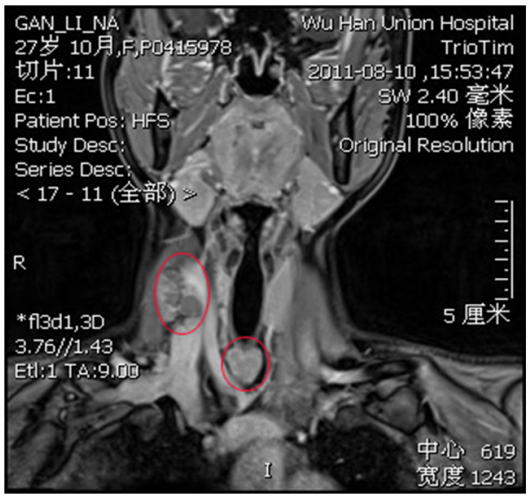

Figure 2. A 28-year-old woman presented with suspicious lymph nodes in central and lateral compartment before reoperation. Node size: 15.25*13.26 mm and 41.6*27.2 mm, respectively. Surgical pathology showed lymph nodal metastases in central and lateral compartment: 8/8 and 9/14.

"Hypoechoic" is the most sensitive characteristic in detection of positive lymph nodes by ultrasound. There was a significant difference (p=0.034) between the detection rate of positive lymph nodes group (59.52%) and negative lymph nodes group (26.32%) with "Hypoechoic" by ultrasound. In addition, a statistically significant difference was observed between the detection rate of positive lymph nodes group and negative lymph nodes group with "microcalcifications" by ultrasound. And there was a statistically significant difference between the detection rate of positive lymph nodes group and negative lymph nodes group with "long diameter" (p=0.011). There were no statistically significant differences between the detection rate of two groups with Other individual characteristics (short diameter, long-diameter≥10 mm, short-diameter≥5 mm, l/s ratio, necrosis or cystic degeneration, medullary thinning or eccentric shift).

The diagnostic value of ultrasound for central lymph nodal metastases: The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of ultrasound for central lymph compartment metastases were 41.67%, 100%, 100%, 44% and 60% respectively. As shown in **Table 5**. Within the individual characteristics of ultrasound, "hypoechoic" had a high sensitivity with 41.67% (**Figure 3**).

The diagnostic value of ultrasound for lateral neck lymph nodal metastases: The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of ultrasound for lateral neck lymph nodal metastases were 77.78%, 50%, 77.78%, 50%, 69.23%, respectively. As shown in **Table 6** on the individual characteristics of ultrasound, "Short diameter≥5 mm" had high sensitivity (63.16%) and specificity (62.5%). "Calcification" and "cystic degeneration" had high specificity (100%) and positive predictive value (100%) (**Figure 4**).

The diagnostic value of MRI compared with ultrasonography

We compared the sensitivity, specificity and accuracy of MRI and ultrasonography in the detection of metastatic nodes involvement. As shown in **Table 7**. There was a statistically significant difference between the sensitivity of MRI and ultrasound in the detection of central lymph nodal metastases (p=0.04). However, there was no statistically significant difference in specificity (p=1.0). There was also no statistically significant difference in the sensitivity

Table 4. The characteristics of positive lymph nodes detected by ultrasound compared with the characteristics of negative lymph nodes

Ultrasonographic features	Lymph node metastases	Negative lymph node metastases	*P* value
Detection rate of lymph node by ultrasound	59.52%	26.31%	0.436
Long diameter	13.70±6.33 mm	12.74±2.86 mm	0.011**
Short diameter	6.272±2.10 mm	5.32±1.80 mm	0.54
l/s ratio*	2.23±0.94	2.63±1.16	0.796
Long-diameter≥10 mm	38.09%	21.05%	0.308
Short- diameter≥5 mm	35.71%	15.79%	0.202
Hypoechoic	59.52%	26.32%	0.034**
Microcalcifications	21.43%	0	0.046**
Necrosis or cystic degeneration	4.76%	0	0.849
Medullary thinning or eccentric shift	9.52%	5.26%	0.954

*Ratio of long and short-diameter; **p<0.05 was considered to be statistically significant.

Table 5. The diagnostic value of ultrasound for central lymph nodal metastases

Ultrasonographic features	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
Hypoechoic	41.67	100.00	100.00	44.00	60.00
Blood flow signals	37.50	100.00	100.00	42.31	57.14
Calcification	16.67	100.00	100.00	35.48	42.86
Long-diameter≥10 mm	20.83	100.00	100.00	36.67	45.71
Short-diameter≥5 mm	20.83	100.00	100.00	36.67	45.71
l/s ratio*≤2	29.17	100.00	100.00	39.29	51.43
Cystic degeneration	4.17	100.00	100.00	32.35	34.29
Medullary thinning	8.33	100.00	100.00	33.33	37.14
overall	41.67	100.00	100.00	44.00	60.00

*Ratio of long and short-diameter.

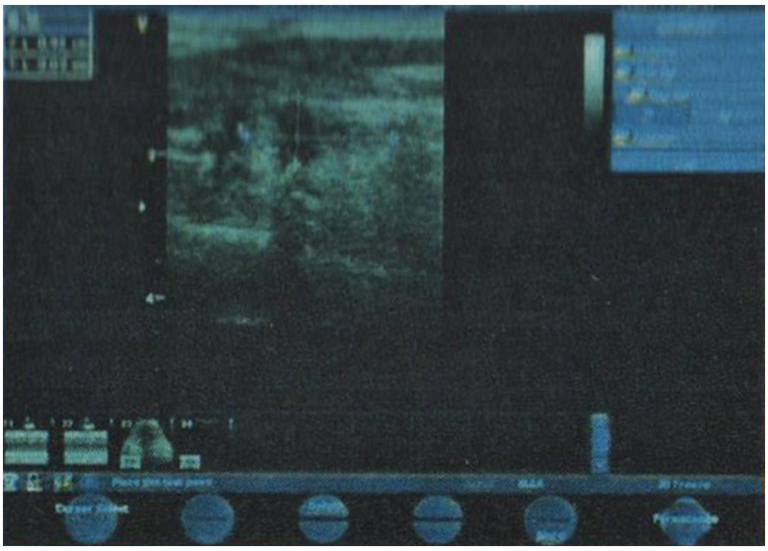

Figure 3. A 38-year-old man presented with suspicious lymph nodes with hypoechoic and calcification in central compartment before reoperation. Node size: 20.2*9.5 mm. Surgical pathology showed lymph nodal metastases in central compartment with 10/10.

(p=1.0) and specificity (p= 0.606) between MRI and ultrasonography in the detection of lateral neck lymph nodal metastases.

Discussion

Differentiated thyroid carcinoma (DTC) is a low-grade malignant tumor with a relatively good prognosis. However, it is still possible for DTC to recur if the initial treatment is inappropriate [2]. Imaging plays a very important role in the surgical evaluation of patients with DTC before reoperation. Currently, the most widely used imaging technologies for recurrent thyroid cancer include ultrasonography, MRI, computed tomog-

Table 6. The diagnostic value of ultrasound for lateral neck lymph nodal metastases

Ultrasonographic features	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
Hypoechoic	88.89	37.50	76.19	60.00	73.08
Blood flow signals	83.33	37.50	75.00	50.00	69.23
Calcification	27.78	100.00	100.00	38.10	50.00
Long-diameter≥10 mm	61.11	50.00	73.33	36.36	57.69
Short-diameter≥5 mm	63.16	62.50	80.00	41.67	62.96
l/s ratio*≤2	27.78	75.00	71.43	31.58	42.31
Cystic degeneration	5.56	100.00	100.00	32.00	34.62
Medullary thinning	11.11	87.50	66.67	30.43	34.62
overall	77.78	50.00	77.78	50.00	69.23

*Ratio of long and short-diameter.

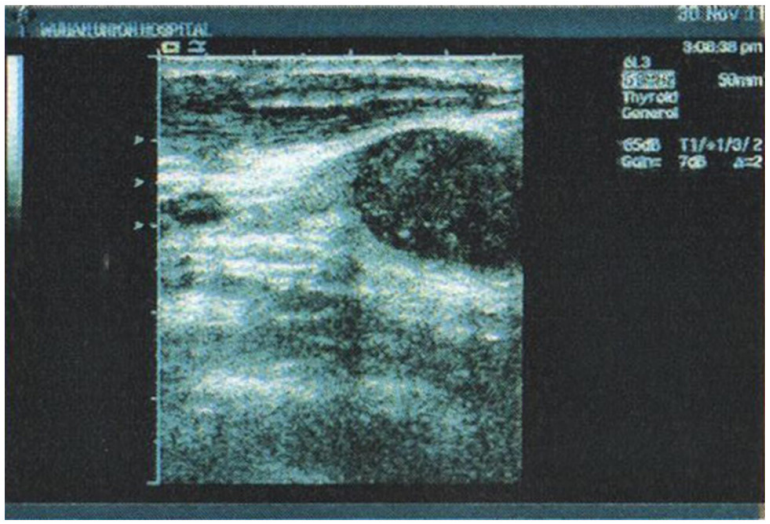

Figure 4. A 27-year-old man presented with suspicious nodes with microcalcification in right lateral compartment before reoperation. Node size: 23.3*17.2 mm. Surgical pathology showed lymph nodal metastases in right lateral compartment with 15/22.

raphy (CT), single photon emission computed tomography (SPECT), and positron emission tomography (PET) [9-13].

Ultrasound scanning is currently the most common imaging tools; it is cheap, easy to perform, non-invasive and easily repeatable; and not affected by iodine uptake of the lesion [14]. Generally, ultrasonographic signs of metastatic lymph nodes tent to be large, round, rich blood -flow signals, hypoechoic, cystic degeneration, irregular shape, loss of hilar architecture, microcalcifications, etc [15]. Wu [16] found that ultrasonography in diagnosis of cervical lymph node metastases had a sensitivity of 63% and specificity of 93%. Nevertheless the ultrasonography has some limitations in diagnosis of central compartment lymph nodal metastases because some of lymph nodes are located in deep regions and easily affected by thyroid tissue, trachea and surrounding structures. It has been reported that ultrasonographic diagnosis of the central lymph nodal metastases has a sensitivity of 40%-63%; significantly lower than the lateral cervical lymph nodal metastases of 82%-93% [17-20].

The disadvantage of ultrasonography leads to increased use of MRI, CT, SPECT and PET/CT as tools for diagnosis of recurrent DTC. ^{131}I SPECT/CT has been used to evaluate patients with DTC, but the residual thyroid tissue after thyroidectomy easily affects uptake of ^{131}I and imaging of metastatic lymph nodes. Moreover, ^{131}I SPECT/CT may influence subsequent ^{131}I therapy. PET/CT scanning is generally used in patients with an elevated serum thyroglobulin (Tg) but a negative ^{131}I whole-body scanning; PET/CT in the diagnosis of papillary thyroid carcinoma metastases has a specificity of up to 90%, but has a low of only 40%-67% [17]. CT and MRI can both show the multifaceted (horizontal, coronal, sagittal) images and show spatial relationships between lesion and surrounding structures. However, CT provides low-resolution images for the soft tissue, and the neck will be exposed to radiation again. A study [21] compared ultrasonography and CT, PET/CT in the diagnosis of cervical lymph nodal metasta-

Table 7. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of MRI and ultrasonography in diagnosis of cervical lymph nodal metastases

Indexes	Central lymph node			Lateral neck lymph node		
	MRI	US	*P* value	MRI	US	*P* value
Sensitivity (%)	75	41.67	0.04**	83.33	77.78	1
Specificity (%)	90.91	100	1.00	25	50	0.606
Accuracy (%)	80	60	0.618	65.39	69.24	1

**p<0.05 was considered to be statistically significant.

ses in patients with DTC, and found there was no significant difference between them. Ultrasonography even had a higher sensitivity and specificity than CT, PET/CT.

In contrast to other types of imaging, MRI has distinct advantages over metastatic thyroid carcinoma, such as high-resolution determination of soft tissue, no radiation exposure, and multi-sequence, multi-parameter imaging capability. However, currently there was limited amount of studies to research MRI diagnostic value of cervical lymph nodal metastases in DTC patients, especially comparison between MRI and ultrasonography.

In this study, we evaluate MRI and ultrasonography diagnostic value of cervical lymph nodal metastases in DTC patients before reoperation. To our knowledge, MRI characteristics of metastatic lymph nodes include enhancing lesions, fusion. Ultrasonographic characteristics include hypoechoic, microcalcifications.

MRI has high sensitivity and specificity for detection of central lymph nodal metastases, but low specificity and negative predictive value for detection of lateral neck lymph nodal metastases. Ultrasound has a high specificity but a low sensitivity in the diagnosis of central lymph nodal metastases. Comparing MRI and ultrasonography in detection of central and the lateral neck lymph nodal metastases, we could conclude that MRI is more sensitive than ultrasonography in diagnosis of central lymph nodal metastases, but there is no significant difference of the lateral neck between them. Therefore, we recommend evaluating central lymph nodal metastases on MRI while evaluating lateral neck lymph nodal metastases by ultrasonography.

In general, our study summarized the diagnosis value of MRI and ultrasound for DTC patients before reoperation. However, there are still several limitations to this research. The main limitations include: our research is based on retrospective data, histological data we collected is not comprehensive; the study is limited by the number of cases and lacking follow-up data. More studies and researches are needed to better understand MRI and ultrasound detection of lymph nodal metastases in DTC patients of reoperation.

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Disclosure of conflict of interest

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