Comparison of Differential Diagnostic Capabilities of ^{201}Tl Scintigraphy and Fine-Needle Aspiration of Thyroid Nodules

Yoshihiro Okumura, Yoshihiro Takeda, Shuhei Sato, Megumi Komatsu, Tomio Nakagawa, Shiro Akaki, Masahiro Kuroda, Ikuo Joja and Yoshio Hiraki

Department of Radiology and Faculty of Health Sciences, Okayama University Medical School, Okayama; and Department of Radiology, Fukuyama National Hospital, Fukuyama, Japan

We assessed the ability of ^{201}Tl planar scintigraphy and fine-needle aspiration (FNA) biopsy to differentiate malignant from benign lesions by comparing the findings of these techniques with those of surgical histopathology for 107 patients with 109 thyroid nodules. **Methods:** ^{201}Tl (74 MBq) was injected intravenously, and an early image and a delayed image were acquired after 10 and 120 min, respectively, for 10 min each. For ^{201}Tl planar scintigraphy, accumulation of the tracer in the nodules was visually scored and the nodules were grouped. Group A showed high activity in both early and delayed images. Group B revealed high activity in only the early image. Group C showed activity in the early image equal to that in normal tissues. Quantitative calculation of the washout rate was less than 0 in group CI and 0 or higher in group CII. Group D revealed low activity in the early image and variable activity in the delayed image. Three differential diagnosis methods were used for ^{201}Tl planar scintigraphy: method 1, in which only group A was considered malignant; method 2, in which both group A and group B were considered malignant; and method 3, in which groups A, B and CI were considered malignant. FNA results were assessed and classified by experienced pathologists. Two differential diagnosis methods were used for FNA: method a, in which malignancy was assigned to class IV (probably malignant or higher), and method b, in which malignancy was assigned to class III (possibly malignant or higher). **Results:** Concerning ^{201}Tl methods 1, 2 and 3, sensitivity was 74.0%, 84.0% and 92.0%, respectively; specificity was 83.1%, 64.4% and 54.2%, respectively; and accuracy was 78.9%, 73.4% and 71.6%, respectively. For FNA, method a and method b had a sensitivity of 36.0% and 50.0%, respectively, and a specificity of 96.6% and 84.7%, respectively. The accuracy of both methods was 68.8%. For follicular lesions, sensitivity ranged from 80.0% to 90.0% for ^{201}Tl scintigraphy and from 10.0% to 30.0% for FNA. **Conclusion:** ^{201}Tl planar scintigraphy was found to be easier to use and more accurate than FNA in the differentiation of diagnosis of benign and malignant thyroid nodules based on visual scoring combined with quantitative evaluation.

Key Words: ^{201}Tl planar scintigraphy; thyroid nodules; fine-needle aspiration

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Thyroid nodules are detected in 4%–7% of adults (*1*). Of the patients with these nodules, malignancy is found in 20% who undergo surgical biopsy, and 2.9% who undergo surgery (*2,3*). Some studies have reported that fine-needle aspiration (FNA) is useful for the differential diagnosis of thyroid nodules (*4–6*), because FNA is safe, simple and inexpensive and has the best predictive value (2). However, much technical skill and clinical experience is required for successful FNA (*7,8*).

^{67}Ga-, ^{201}Tl- and ^{99m}Tc-labeled (^{99m}Tc-methoxyisobutyl isonitrile [MIBI] and ^{99m}Tc-tetrofosmin) compounds have been researched for the evaluation of thyroid nodules (*4,9–14*). ^{201}Tl is believed to be the most suitable and has frequently been reported to be useful for the differential diagnosis of thyroid nodules (*9–11,15–18*).

This study compared the differential diagnostic capabilities of FNA and ^{201}Tl planar scintigraphy.

MATERIALS AND METHODS

The study included 107 patients (18 males, 89 females; age range 16–84 y; mean age [±SD] 54.8 ± 15.5 y) with 109 thyroid nodules (size range 7–75 mm, mean size 31.5 ± 15.1 mm). The nodules were detected sonographically and confirmed histopathologically after surgery. The patients underwent both ^{201}Tl planar scintigraphy and FNA.

Histopathologic examination revealed that 59 of the nodules were benign (45 cases of follicular adenoma, 12 of adenomatous hyperplasia and 2 of oncocytoma) and 50 were malignant (27 cases of papillary carcinoma, 20 of follicular carcinoma, 1 of undifferentiated carcinoma and 2 of medullary carcinoma).

In ^{201}Tl planar scintigraphy, ^{201}Tl (74 MBq) was injected intravenously, an early image was acquired after 10 min and a delayed image was acquired after 120 min. $^{99m}TcO_4^-$ (185 MBq) was injected intravenously after the ^{201}Tl early image was acquired.

The effective field of view of the imaging system was 40 cm in diameter. Imaging parameters included a window level of 70 keV for ^{201}Tl and 140 keV for $^{99m}TcO_4^-$, a window width of ±10% for both compounds, a preset time of 10 min for ^{201}Tl and 5 min for $^{99m}TcO_4^-$ and a maximum preset count of 256 counts per pixel.

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For correspondence or reprints contact: Yoshihiro Okumura, Department of Radiology, Okayama University Medical School, 2-5-1 Shikata-cho, Okayama 700-8558, Japan.

A low-energy, high-resolution pinhole collimator was used. The data acquisition matrix was 256 × 256 and the display matrix was 512 × 512.

Scintigraphic Interpretation

For ^{201}Tl scintigraphy, accumulation of the tracer in the nodules was visually scored. Markedly higher accumulation in nodules than in normal tissues was scored 4. Slightly higher accumulation in nodules than in normal tissues was scored 3. Accumulation in nodules comparable with that in normal tissues was scored 2. Lower accumulation in nodules than in normal tissues, but no cold accumulation, was scored 1. Cold accumulation was scored 0.

Interpretation was performed by four radiologists, including three specialists in nuclear medicine, with 10 years or more of experience. The final interpretation was based on consensus.

On the basis of the visual score, nodular lesions were classified as follows. Group A included lesions scored 3 or higher on both early and delayed images. Group B included lesions scored 3 or higher on the early image and 2 or lower on the delayed image. Group C included lesions scored 2 on the early image and any score on the delayed image. Group D included lesions scored 1 or lower on the early image and any score on the delayed image. Group C was further subdivided into two groups based on quantitative calculation of the washout rate (Group CI: less than 0, Group CII: 0 or higher).

For quantitative evaluation in ^{201}Tl scintigraphy, the largest possible region of interest not exceeding the target region was manually placed on the tumor and on normal thyroid tissue on the opposite side, and the tumor-to-background ratio (T/B), as a numerical value per pixel, was calculated. The washout rate was obtained as follows.

$$[\mathrm{T/B\ (early)} - \mathrm{TB\ (delayed)}]/\mathrm{T/B\ (early)} \times 100\ (\%)$$

Three methods for the differential diagnosis of thyroid nodules using scintigraphy were studied. The methods represented differing determinations of which groups were considered malignant: in method 1, only group A was considered malignant; in method 2, both groups A and B were considered malignant; in method 3, group CI was considered malignant in addition to groups A and B; and in method 4, group CII was considered malignant in addition to groups A and B.

Analysis of Cytologic Data

FNA was performed by puncturing the thyroid nodule using a syringe fitted with a 23-gauge needle. Cells were drawn into the syringe, spread on a glass slide and stained by the Papanicolaou or Giemsa method. The results of the examination were observed and classified by experienced pathologists qualified by the Japanese Society of Cytodiagnosis. Class I included normal cells; class II, abnormal cells; class III, possibly malignant cells; class IV, probably malignant cells; and class V, definitely malignant cells. With regard to differential diagnosis by FNA, two methods for determining malignancy were investigated: a, in which malignancy was assigned to class IV or higher, and b, in which malignancy was assigned to class III or higher.

Statistical Analysis

For statistical analysis of visual and quantitative evaluation of scintigraphic data between groups, the Fisher protected least significant difference test was used. The Wilcoxon signed rank test was used for within-group statistical analysis. The results were considered statistically significant when the risk ratio was 5% or lower.

RESULTS

Scintigraphic Data

Tables 1 and 2 summarize the scintigraphic data. Of the 109 nodules investigated, high accumulation (score 3 or 4) was recognized on early ^{201}Tl images of 63 nodules, with prolonged uptake seen for 47 nodules (group A) and washout almost the same as that in normal tissues (score 2) seen for 16 nodules (group B). Furthermore, of the 109 nodules, accumulation was almost the same as that in normal thyroid tissue (score 2) on early ^{201}Tl images of 17 nodules (group C) (CI: 10 nodules, CII: 7 nodules) and lower than that in normal tissues (score 1). For 16 nodules, the accumulation seen on delayed images was the same as that in normal thyroid tissue (score 2), and accumulation lower than that in normal thyroid tissue (score 0 or 1) was recognized on early ^{201}Tl images of 29 nodules (group D).

The mean visual score (±SD) for early images of group A was 3.6 ± 0.5, which was significantly higher than that of the other groups ($P < 0.01$), and the visual score of group B was significantly higher than that of groups CI, CII and D ($P < 0.01$). The visual score for delayed images of group A was 3.3 ± 0.5, which was significantly higher than that of the other groups ($P < 0.01$). No significant differences were observed in the visual score for delayed images of group B compared with that for delayed images of groups CI, CII and D. In group D, the visual scores were 0.9 ± 0.3 for early images and 1.3 ± 0.7 for delayed images, both of which were significantly lower than the score of the other group ($P < 0.01$).

In groups A and B, the visual score for delayed images was significantly lower than that for early images. In addition, the visual score for delayed images was significantly higher than that for early images of group D ($P < 0.01$).

TABLE 1
Visual Interpretation of Washout Patterns on ^{201}Tl Images

Group	Early score	Delayed score
A (n = 47)	3.6 ± 0.5*	3.3 ± 0.5*
B (n = 16)	3.1 ± 0.3†	1.9 ± 0.3
C (n = 17)		
CI (n = 10)	2.0 ± 0	1.9 ± 0.3
CII (n = 7)	2.0 ± 0	2.0 ± 0
D (n = 29)	0.9 ± 0.3*	1.3 ± 0.7

*$P < 0.01$ versus other groups, Fisher protected least significant difference (PLSD).

†$P < 0.01$ versus groups CI, CII and D, Fisher PLSD.

Data shown are mean ± SD of visual evaluation score in five groups.

TABLE 2
Scintigraphic Data for Washout Patterns on ^{201}Tl Images

Group	Tumor-to-background ratio		Washout rate (%)
	Early scan	Delayed scan	
A (n = 47)	1.8 ± 0.6*	1.5 ± 0.5*	15 ± 29
B (n = 16)	1.3 ± 0.3†	1.0 ± 0.1	19 ± 12
C (n = 17)			
CI (n = 10)	0.8 ± 0.1	1.0 ± 0.2	−20 ± 14‡
CII (n = 7)	1.2 ± 0.3	1.0 ± 0.2	16 ± 16
D (n = 29)	0.7 ± 0.2§	0.8 ± 0.1	−38 ± 36‡

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*$P < 0.05$ versus other groups, Fisher protected least significant difference (PLSD).

†$P < 0.05$ versus groups CI and D, Fisher PLSD.

‡$P < 0.01$ versus groups A, B and CII, Fisher PLSD.

§$P < 0.01$ versus groups A and CII, Fisher PLSD.

Data shown are mean ± SD of visual evaluation score in five groups.

Tumor-to-Background Ratio

The T/B for early images of group A was found to be significantly higher than that of the other groups ($P < 0.01$), and the T/B for early images of group D was significantly lower than that of groups B and CII ($P < 0.01$). In addition, the T/B for early images of Group B was significantly higher than that of groups CI and D ($P < 0.05$); however, no significant difference was noted compared with group CII.

In group A, the T/B for delayed images was found to be significantly higher than that of the other groups ($P < 0.05$), and the T/B for delayed images of group D was not significantly lower than that of the other groups except group A. No significant differences were noted in the T/B for delayed images of groups B and CI compared with that of group CII.

Washout Rate

As Table 2 shows, a significant difference was recognized between the washout rate in group CI with progressive accumulation and that in the other groups except for group D ($P < 0.001$), but no significant differences were noted among groups A, B and CII.

TABLE 3
Malignancy Rate Determined by Washout Patterns on ^{201}Tl Images

Group	No. of benign nodules	No. of malignant nodules	Malignancy rate (%)
A (n = 47)	10	37	78.7
B (n = 16)	11	5	31.3*
C (n = 17)			
CI (n = 10)	6	4	40.0*
CII (n = 7)	6	1	14.3*
D (n = 29)	26	3	10.3*

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*$P < 0.01$ versus group A.

Malignancy Rate for Washout Patterns on ^{201}Tl Imaging

Based on the scintigraphic data shown in Table 3, in Group A 10 of 47 nodules were benign (5 cases of follicular adenoma, 3 of adenomatous hyperplasia and 2 of oncocytoma) and 37 were malignant (19 cases of papillary carcinoma, 16 of follicular carcinoma, 1 of undifferentiated carcinoma and 1 of medullary carcinoma). This malignancy rate—78.7%—was higher than that in the other groups. In group B, which included 16 nodules, 11 nodules were benign (8 cases of follicular adenoma and 3 of adenomatous hyperplasia) and 5 were malignant (3 cases of papillary carcinoma, 1 of follicular carcinoma and 1 of medullary carcinoma), for a malignancy rate of 31.3%. In group CI, which included 10 nodules, 6 nodules were benign (follicular adenoma) and 4 were malignant (3 cases of papillary carcinoma and 1 of follicular carcinoma) for a malignancy rate of 40.0%. In group CII, which included 7 nodules, 6 nodules were benign (4 cases of follicular adenoma and 2 of adenomatous hyperplasia) and 1 was malignant (follicular carcinoma), for a malignancy rate of 14.3%. In group D, which included 29 nodules, 26 nodules were benign (22 cases of follicular adenoma and 4 of adenomatous hyperplasia) and 3 were malignant (2 cases of papillary carcinoma and 1 of follicular carcinoma), for a malignancy rate of 10.3%.

Malignancy Rate for Fine-Needle Aspiration

As Table 4 shows, of 20 nodules found to belong to class IV or higher, 2 were benign (1 case each of follicular adenoma and oncocytoma) and 18 were malignant (15 cases of papillary carcinoma, 2 of follicular carcinoma and 1 of undifferentiated carcinoma), for a malignancy rate of 90.0%. Of 14 nodules that were class III, 7 were benign (follicular adenoma) and 7 were malignant (3 cases of papillary carcinoma and 4 of follicular carcinoma), for a malignancy rate of 50.0%. Of 75 nodules that were class II or lower, 50 were benign (37 cases of follicular adenoma, 12 of adenomatous hyperplasia and 1 of oncocytoma) and 25 were malignant (9 cases of papillary carcinoma, 14 of follicular

TABLE 4
Malignancy Rate Determined by Fine-Needle Aspiration

Class	No. of benign nodules	No. of malignant nodules	Malignancy rate (%)
V (n = 10)	0	10	100.0
IV (n = 10)	2	8	80.0
III (n = 14)	7	7	50.0
II (n = 61)	40	21	34.4
I (n = 14)	10	4	28.6
≥IV (n = 20)	2	18	90.0
≥III (n = 34)	9	25	73.5
≤II (n = 75)	50	25	33.3

Class V = definitely malignant cells; class IV = probably malignant cells; class III = possibly malignant cells; class II = abnormal cells; class I = normal cells.

TABLE 5
Comparison of ^{201}Tl Scintigraphy and FNA in Detecting Follicular Lesions

	^{201}Tl scintigraphy group											
FNA	A		B		CI		CII		D		Total	
class	T	M	T	M	T	M	T	M	T	M	T	M
V	1	1	0	0	0	0	0	0	0	0	1	1
IV	1	1	0	0	0	0	0	0	2	0	3	1
III	7	4	0	0	1	0	0	0	2	0	10	4
II	8	7	6	1	6	1	3	1	17	1	40	11
I	4	3	2	0	0	0	2	0	3	0	11	3
Total	21	16	8	1	7	1	5	1	24	1	65	20

FNA = fine-needle aspiration; T = total no. of nodules; M = no. of malignant nodules.

TABLE 7
Comparison of ^{201}Tl Scintigraphy and FNA in Detecting Thyroid Nodules

	^{201}Tl scintigraphy group											
FNA	A		B		CI		CII		D		Total	
class	T	M	T	M	T	M	T	M	T	M	T	M
V	9	9	1	1	0	0	0	0	0	0	10	10
IV	7	7	0	0	0	0	0	0	3	1	10	8
III	10	6	1	1	1	0	0	0	2	0	14	7
II	16	12	11	3	9	4	4	1	21	2	61	22
I	5	3	3	0	0	0	3	0	3	0	14	3
Total	47	37	16	5	10	4	7	1	29	3	109	50

FNA = fine-needle aspiration; T = total no. of nodules; M = no. of malignant nodules.

carcinoma and 2 of medullary carcinoma), for a malignancy rate of 33.3%.

Follicular Lesions

The diagnostic capabilities of the various methods were compared for 65 follicular lesions (45 cases of follicular adenoma and 20 of follicular carcinoma, as summarized in Tables 5 and 6. Sensitivity and accuracy for follicular carcinoma based on the cytologic data were markedly lower than those based on the scintigraphic data, whereas specificity was higher.

Comparison of Differential Diagnostic Capabilities for Thyroid Nodules

Diagnostic capabilities for ^{201}Tl scintigraphy are shown in Tables 7 and 8.

With the combination of methods 3 and b, 47 of 50 malignant nodules (94.0%) were detected and only 3 malignant nodules (6.0%) showed false-negative results.

Figures 1 and 2 show the visual score, the T/B of ^{201}Tl scintigraphy and the classification of thyroid tumors by FNA.

DISCUSSION

Washout of ^{201}Tl has been reported to occur later for differentiated thyroid carcinoma than for thyroid adenoma (*19*). Studies using time-activity curves have shown that, for scintigraphic data, the time required for the number of counts to decrease to one half is frequently longer for malignant tumors than for benign tumors, with values of 40 min or longer (*20*). Another report has shown that visual evaluation of images obtained 120 to 180 min after ^{201}Tl injection is useful in the differential diagnosis of thyroid tumors (*21*). ^{201}Tl SPECT is much more effective than planar imaging in the detection of metastases from differentiated thyroid cancer (*22*).

To assess the usefulness of thyroid scintigraphy using ^{201}Tl in the differential diagnosis of thyroid nodules, further studies were performed taking into account the results of partial quantitative evaluation, in addition to visual evaluation, of ^{201}Tl data. For visual evaluation alone (Table 1), higher visual scores were obtained for both early and delayed images of group A compared with those of groups B, CI, CII and D. Patients who had high activity on delayed

TABLE 6
Comparison of ^{201}Tl Scintigraphy and Fine-Needle Aspiration in Detecting Follicular Lesions

	^{201}Tl scintigraphy								Fine-needle aspiration						
	Group					Method			Class					Method	
Index	A	A–B	A–CI	A–CII	A–D	1	2	3	V	V–IV	V–III	V–II	V–I	a	b
Sensitivity	80.0	85.0	90.0	95.0	100.0	80.0	85.0	90.0	5.0	10.0	30.0	85.0	100.0	10.0	30.0
Specificity	88.9	73.3	60.0	51.1	0.0	88.9	73.3	60.0	100.0	95.6	82.2	17.8	0.0	95.6	82.2
Accuracy	86.2	76.9	69.2	64.6	30.8	86.2	76.9	69.2	70.8	69.2	66.2	38.5	30.8	69.2	66.2

Method 1 = only group A was considered malignant; method 2 = both groups A and B were considered malignant; method 3 = groups A, B and CI were considered malignant; method a = malignancy was assigned to class IV or higher; method b = malignancy was assigned to class III or higher.

All values are percentages.

TABLE 8

Comparison of ^{201}Tl Scintigraphy and Fine-Needle Aspiration in Detecting Thyroid Nodules

	^{201}Tl scintigraphy								Fine-needle aspiration						
	Group					Method			Class					Method	
Index	A	A–B	A–CI	A–CII	A–D	1	2	3	V	V–IV	V–III	V–II	V–I	a	b
Sensitivity	74.0	84.0	92.0	94.0	100.0	74.0	84.0	92.0	20.0	36.0	50.0	94.0	100.0	36.0	50.0
Specificity	83.1	64.4	54.2	44.1	0.0	83.1	64.4	54.2	100.0	96.6	84.7	18.6	0.0	96.6	84.7
Accuracy	78.9	73.4	71.6	67.0	45.9	78.9	73.4	71.6	63.3	68.8	68.8	53.2	45.9	68.8	68.8
PPV	78.7	66.7	63.0	58.8	45.9	78.7	66.7	63.0	100.0	90.0	73.5	49.5	45.9	90.0	73.5
NPV	79.0	82.6	88.9	89.7	—	79.0	82.6	88.9	59.6	64.0	66.7	78.6	—	64.0	66.7

Method 1 = only group A was considered malignant; method 2 = both groups A and B were considered malignant; method 3 = groups A, B and CI were considered malignant; method a = malignancy was assigned to class IV or higher; method b = malignancy was assigned to class III or higher; PPV = positive predictive value; NPV = negative predictive value.

All values are percentages.

images also had high activity on early images, compared with patients who did not have high activity on delayed images. Moreover, visual scores of delayed images of group D had less activity than visual scores of the other groups. Patients who had low activity on early images also had lower activity on late images, compared with patients for whom activity was either equal or higher on the early images. The results of this study agree with those of Derebek et al. (*23*). For quantitative evaluation alone (Table 2), T/Bs for group A were also found to be almost identical to those obtained by visual evaluation alone of the delayed images. In group A, the differential diagnosis of thyroid nodules can probably be based on visual evaluation alone, because the results of visual and quantitative evaluation were the same.

Visual evaluation of delayed images obtained using ^{201}Tl planar scintigraphy has been reported to be useful for the differentiation of thyroid nodules (*21*). In this study, the malignancy rate in group A, which showed high activity on both early and delayed images, was high (78.7%), and the sensitivity of method 1, in which only group A was considered to be malignant, was 74.0%. On the other hand, some researchers have reported that early ^{201}Tl scintigraphic images are useful for the differentiation of thyroid nodules (*23*). Accordingly, method 2, in which groups A and B (in which early images showed high activity) were considered to be malignant, was further investigated. When method 2 was used, specificity decreased to 64.4% from 83.1%, because 11 of 16 benign nodules in group B were incorrectly diagnosed as malignant. However, sensitivity increased to 84.0%, because 5 additional malignant nodules were detected. Some studies have reported that washout of ^{201}Tl is delayed in thyroid carcinoma (*19,20*). Therefore, the nodules that showed comparable accumulation on early images were evaluated quantitatively and by classification into either group CI, in which ^{201}Tl was not washed out, or group CII, in which ^{201}Tl was washed out. Thus, method 3, in which group CI was included with groups A and B, was also added. These groups were considered malignant in method 3. Using this method, the sensitivity increased to 92.0%, because 4 additional malignant nodules were detected, but specificity decreased to 54.2%, because 6 of 10 benign nodules in group CI were diagnosed as malignant.

The sensitivity of ^{201}Tl planar scintigraphy in this study was between 74.0% and 100.0%, which is within the range of 25% to 100% that has generally been reported (*21,23–25*). In addition, the specificity was between 54.2% and 83.1%, which is almost the same as the 62.0%–100% range that has been reported. When method 3 was used, the number of false-negative findings was reduced compared with methods 1 and 2, with excellent sensitivity (92.0%). Method 3 was therefore considered to be useful for screening for malignant nodules. To detect malignant nodules, one should qualitatively evaluate for nodules showing comparable accumulation on early images. Method 1 is considered

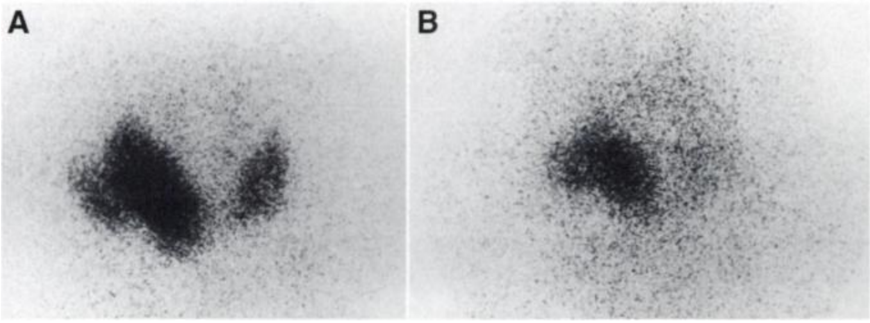

FIGURE 1. A 61-y-old woman in group A with tumor in lower right lobe of thyroid gland. Visual scores and T/Bs for ^{201}Tl scintigraphy were 4 and 2.1, respectively, for early image (A) and 4 and 4.0, respectively, for delayed image (B). Class III papillary carcinoma was diagnosed by FNA. Accumulation in lymph node metastases is seen outside right lobe.

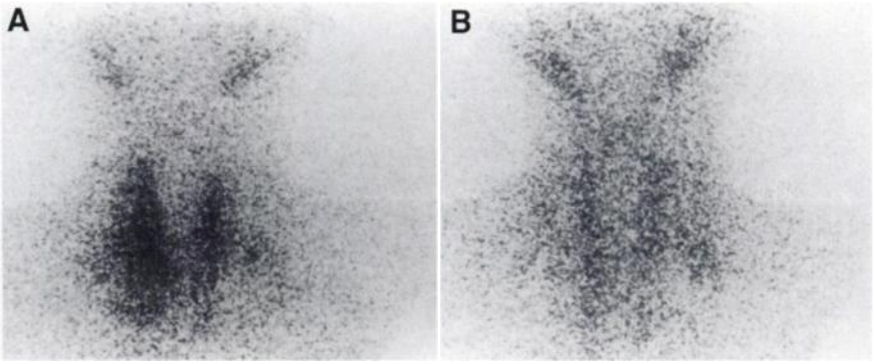

FIGURE 2. A 56-y-old woman in group B with tumor in lower right lobe of thyroid gland. Visual scores and T/Bs for ^{201}Tl scintigraphy were 3 and 1.2, respectively, for early image (A) and 2 and 0.9, respectively, for delayed image (B). Class II follicular carcinoma was diagnosed by FNA.

to be useful for identifying false-positive findings, because specificity was high, although sensitivity was low. The malignancy rate in classes IV and V by FNA was 90%, and that in class III was 50%. In comparisons of methods a and b, specificity was 96.6% for method a and 84.7% for method b, values that were within the 72%–100% range that has generally been reported (*26,27*), resulting in superior results compared with ^{201}Tl planar scintigraphy. On the other hand, sensitivity was only 36.0% for method a and 50% for method b, values that were considerably lower than the 65.0%–98% range that has been reported (*28–30*) and the results for ^{201}Tl planar scintigraphy. The false-negative rate was 50% by method b, or 1.3%–15% higher than that generally reported (*2,28,31–33*), because of a large number of follicular lesions (59.6%, 65/109 nodules). The differential diagnosis of follicular adenoma and follicular carcinoma by aspiration biopsy is considered limited (*2,5,34–36*). At least one of three findings (capsular or vascular invasion and metastasis) must be seen. Accordingly, aspiration biopsy (findings at the cell level) is not useful for the differential diagnosis of thyroid nodules. In this study, the sensitivity of ^{201}Tl planar scintigraphy was superior to that of FNA (80% for method 1 and 90% for method 3, compared with 10% for method a and 30% for method b). Furthermore, in this study, FNA was performed only once. In addition, much technical skill and clinical experience is required for sampling and pathologic diagnosis with FNA (*7*). Some researchers have reported that between 3% and 30% of samples are inappropriate because of errors either in sampling or in pathologic diagnosis (*26,30,37*), resulting in lower sensitivity. ^{201}Tl scintigraphy is considered to be useful for the evaluation of follicular lesions that are difficult to differentiate by aspiration biopsy.

For differential diagnosis of thyroid nodules with ^{201}Tl planar scintigraphy and FNA, the following scheme is suggested. If FNA can be performed, method b should be selected because of its high specificity. Surgery should be considered in cases found to be class III or higher with FNA. If FNA cannot be performed or shows class II or lower, ^{201}Tl scintigraphy should be performed. For group A lesions for which both early and delayed images reveal high activity, surgery should be considered because of the high likelihood of malignancy. Therefore, delayed images are clinically important in determining whether surgery is required. For lesions found to be group B or CI by ^{201}Tl scintigraphy, surgery is also desirable because the moderate likelihood of malignancy. For lesions found to be group CII or D by ^{201}Tl scintigraphy, ^{201}Tl scintigraphy should be performed again and the lesions followed up, because malignancy may be present despite the low malignancy rates usually found in these groups.

With the combination of methods 3 and b, 47 of 50 malignant nodules (94.0%) were detected and only 3 malignant nodules (6.0%) showed false-negative results.

The sensitivity of method 3 alone by ^{201}Tl scintigraphy was almost as high as that of the combination of methods 3 and b. Method 3 by ^{201}Tl planar scintigraphy was found to be easier and more accurate than FNA in the differential diagnosis of benign and malignant thyroid nodules based on visual scoring combined with quantitative evaluation.

CONCLUSION

FNA has been widely used for differential diagnosis of thyroid nodules (*4–6*). However, the results strongly depend on the technical skill and clinical experience of the person performing the procedure (*7,8*). On the other hand, ^{201}Tl scintigraphy, as performed in this study, allows the accumulation of tracer in the lesion to be visually scored in a single examination. In addition, the washout pattern can be classified by adding partial quantitative evaluation, permitting thyroid nodules to be differentiated easily and accurately.

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