Methionyl-tRNA synthetase 1 expression, the possibility as a diagnostic and prognostic factor in papillary thyroid cancer

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A Dissertation Submitted
to the Department of Medicine
and the Graduate School of Yonsei University
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy in Medical Science

Seulkee Park

December 2024

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The Graduate School
Yonsei University
December 2024

ACKNOWLEDGEMENTS

This dissertation has been the biggest challenge in my life thus far. Without the support, patience and guidance of the following individuals, I would not have succeeded.
First, I express my deepest gratitude to Prof. Woong Youn Chung, for his continuous support during my career and research. I cannot imagine having a better advisor and mentor during my research career. I also thank my thesis committee members: Profs. Seok-Mo Kim, Sung Ill Jang, Su-Jin Shin, and Kyu Eun Lee, for their insightful comments and encouragement.
I thank my colleagues, especially Profs. Im-kyung Kim, Jee Yeon Lee, Hyejeong Park, and Jun Sung Lee, for their advice and careful consideration. I express sincere gratitude to my friend, Euisun Oh, for emotional support throughout my life.
Finally and most importantly, this is dedicated to my parents, Sunhong Park and Yunsook Lee; my brother, Hanmoy Park; my husband, Kyuil Yeon; and my sons, June and Gunn, who encouraged and supported me on this memorable journey.

December 2024

Seulkee Park

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ABSTRACT

The Methionyl-tRNA synthetase 1 expression, the possibility as a diagnostic and prognostic factor in papillary thyroid cancer

Background: Methionyl-tRNA synthetase 1 (MARS1) is a critical enzyme for translation initiation that catalyzes, the transfer of Met to the initiator tRNA. Recent studies have evaluated MARS1 expression as a diagnostic tool and prognostic predictor in several cancers types. In the present study, we aimed to determine how MARS1 is expressed in thyroid tissue and whether there are differences between normal follicular and papillary thyroid carcinoma (PTC) cells.

In addition, we aimed to determine whether MARS1 expression can complement conventional cell staining methods currently used for PTC diagnosis and can thus be used as a prognostic predictor.

Methods: We compared MARS1 expression in thyroid cancer and normal thyroid follicular cells using fine needle aspiration biopsy in 103 patients. Next, we compared MARS1 expression in patients with (n=50) and without (n=50) lateral neck metastases using immunohistochemical analysis of archived tissues from 100 patients. During the clinical follow-up period of these patients, we investigated whether MARS1 expression differed with recurrence.

Results: The average MARS1 expression grade of PTC cells was 2.59 and that of normal follicular cells was 1.28. MARS1 expression differed significantly between the two groups ($p<0.001$). A significant difference in the average MARS1 expression grade of PTC cells between the metastatic and non-metastatic groups ($p<0.05$) was observed. In addition, a significant difference was observed in the average MARS1 expression grade between the lymph nodes of the metastatic group and the PTC cells of the non-metastatic group ($p<0.05$).

Conclusions: Our analysis suggests that MARS1 can be used as a complementary marker to the current fine-needle aspiration biopsy tissue staining method. In addition, although MARS1 is not a direct prognostic predictor of PTC recurrence, it is related to lateral neck lymph node metastasis, and may therefore be a predictor of advanced thyroid cancer.

Key words: Thyroid cancer, Papillary thyroid cancer, Methionyl-tRNA synthetase 1, Diagnostic marker, Prognostic marker

1. INTRODUCTION

Thyroid nodules are generally detected using ultrasound performed during cervical screening(1). Further determination of whether there is a need for additional observation or tests is based on the size and shape of the nodules and whether they are classified as hot or cold. Fine needle aspiration biopsy (FNAB) is an important and widely accepted method for diagnosing thyroid nodules (2).

The FNAB results were divided into six categories, based on the Bethesda system for reporting thyroid cytopathology (TBSRTC), in which surgical treatment is generally performed in Categories 5 and 6 (3). However, in Categories 3 and 4, the Bethesda system is ambiguous regarding whether surgery is required. Category 3 refers to atypical cells, and surgical treatment is generally considered when successive FNAB results indicate Category 3 (4). Category 4 refers to follicular neoplasms, in which case, it is not possible to confirm the possibility of malignancy using FNAB (5). Malignancies in Category 4 can only be confirmed in the final pathology after surgery. In Categories 3 and 4 of the TBSRTC, excessive tests or surgical treatments may be performed. This can be considered a limitation of the general FNAB tissue staining method currently used (6).

Methionyl-tRNA synthetase 1 (MARS1) plays an essential role in initiating translation by transferring Met to the initiator tRNA and has a close relationship with aminoacyl-tRNA synthetase-interacting multifunctional protein-3 (AIMP3)/p18, a potent tumor suppressor that is translocated to the nucleus for DNA repair upon DNA damage (7). MARS1 is an aminoacyl-tRNA synthetase (ARS), that resulates cellular protein synthesis. (8, 9). Several recent studies have indicated that ARSs are also involved in various physiological and pathological processes, particularly tumorigenesis. ARSs can be used as diagnostic and prognostic biomarkers in patients with cancer. In addition, several studies have reported malignancies based on elevated MARS1 expression detected using immunostaining (10).

In the present study, we aimed to examine whether MARS1 expression differs between normal follicular cells and papillary thyroid cancer (PTC) cells in thyroid tissues and to verify whether it can supplement the limitations of current cell staining methods.

2. METHODS

2.1. Study design

In this prospective study, tissue samples were obtained from patients who underwent surgical treatment for PTC. In the first part of the study, 103 patients diagnosed with PTC between May 8, 2020 and June 8, 2022 were selected to compare MARS1 expression between PTC and normal follicular cells obtained from thyroid FNAB. We observed the pattern of MARS1 expression in normal thyroid tissue and various lesions using experimental conditions and cytology slide

production methods. In addition, we verified whether differences in MARS1 expression between normal thyroid tissue and PTC have a diagnostic value.

In the second part of the study, we selected 100 patients who underwent bilateral thyroidectomy with or without modified radical neck dissection (RND) between July 09, 2015, and December 14, 2017, and compared MARS1 expression of stored tissue blocks. Of the 100 patients, 50 showed lateral neck metastasis and the remaining 50 showed no metastasis. Modified radical neck dissection was performed in patients with lateral neck node metastases and the presence of lateral neck lymph nodes was confirmed using permanent pathology. We observed differences in MARS1 expression between the two groups and verified whether MARS1 can be used as a predictor of thyroid cancer recurrence during the clinical follow-up period. This study was approved by the Institutional Review Board (IRB) of Gangnam Severance Hospital, Yonsei University College of Medicine (IRB protocol: 3-2020-0309). Because of the retrospective nature of the study, the requirements for patient approval and informed consent ware waived by the IRB.

2.2. Immunohistochemical (IHC) staining

IHC staining for MARS1 was performed on paraffin-embedded thyroid tissue blocks cut into 4μm sections using an automated IHC stainer (BenchMark XT; Ventana Medical Systems, Tucson, AZ, USA) with a primary antibody against human MARS1 (1:300; 0.2 mg/mL; Bicbio Inc., Suwon, South Korea). It is possible that MARS1 expression differs depending on the cytology slide method; therefore, all three methods, conventional pap smears, thin preps, and sure paths, were performed.

In the first 18 cases in this prospective study, the antibody dilution factor and antigen retrieval time were varied to determine the optimal conditions for MARS1 expression. The antibody dilution factor was 1: 10000, 1: 12800, 1: 15000, and 1: 20000, and antigen retrieval duration were 16, 24, and 32 min. In the subsequent cases, antibody dilution factor 1: 10000 and antigen retrieval time was 16 min for thin prep and sure path, and 24 min for conventional pap smear.

2.3. Interpretation of MARS1 expression

MARS1 expression in PTC and normal follicular cells was categorized into four grades (Grade 0, 1, 2, and 3) depending on the intensity of expression. If the MARS1 expression intensity in the thyroid tissue was similar to that in the parathyroid gland or germinal center cells of the lymphoid tissue, it was classified as Grade 3. If the MARS1 expression intensity in the thyroid tissue was similar to that in the benign thyroid follicles, it was classified as Grade 1. MARS1 expression intensity between Grades 1 and 3 was classified as Grade 2. If MARS1 was not expressed in the sample, it was classified as Grade 0. Figure 1 shows Grades 1, 2, and 3 MARS1 expression in thyroid tissues, along with Grade 3 MARS1 expression in metastatic PTC cells in the lymph nodes.

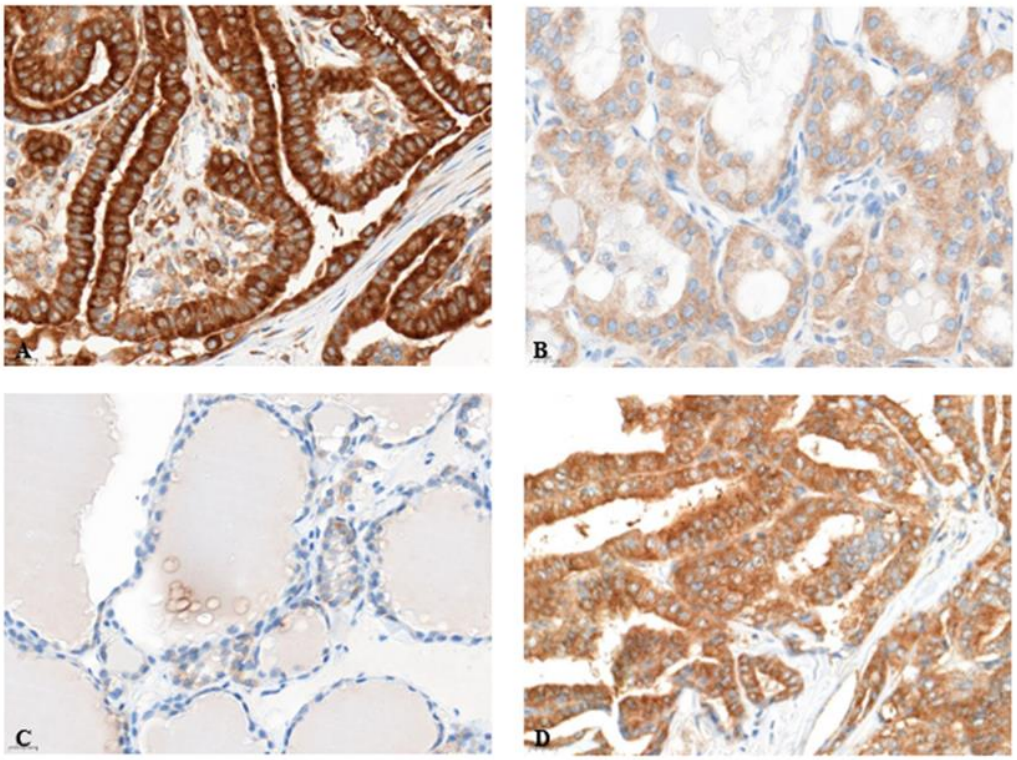


Figure 1. MARS1 expression in thyroid tissues. Grades 3 (A) and 2 (B) expression in papillary thyroid carcinomas (PTC) cells, and grade 1 (C) expression in normal thyroid follicular cells (Magnification: 400×). Grade 3 expression in metastatic PTC cells in lymph node (D) (Magnification: 400×).

2.4. Statistical analysis

All statistical analyses were performed using the SPSS 27 statistical software. Fisher's exact test or the chi-square test was used to compare categorical variables. The Student's t-test was used to compare continuous variables, which are presented as mean ± standard deviation(SD). Univariate analysis was performed using the log-rank test, and multivariate analysis was performed using the Cox proportional hazard model. The Chi-square test, and analysis of variance(ANOVA) were used to estimate the differences. Statistical significance was set at $p<0.05$.

3. RESULTS

3.1. MARS1 expression in thyroid tissues

We obtained both normal and tumor tissues from 103 patients, five of whom were excluded because their IHC evaluation results were unsuitable. In thyroid cancer lesions, MARS1 expression was commonly measured as grade 3, whereas in benign lesions, MARS expression was observed as grade 2. Therefore, MARS 1 expression was increased in thyroid nodules but, not in normal thyroid tissues. (Figures 2 and 3). No change was observed in MARS1 expression grade based on variations in the cytology slide method, antibody dilution factor rate, and antigen retrieval duration.

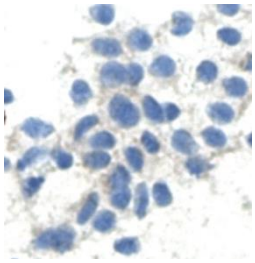
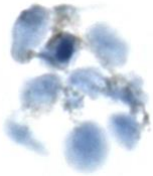
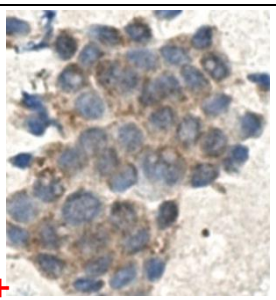
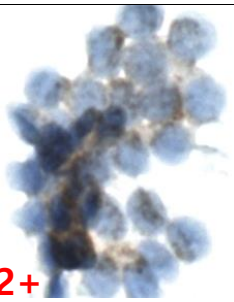
	Cytology slide method / Antibody dilution factor		
	Smear 1:12800 MARS1 ICC grade	**Surepath 1:12800 MARS1 ICC grade**	**Thin prep 1:12800 MARS1 ICC grade**
Normal	 1+	 1+	 1+
Cancer	 3+	 2+	 2+

Figure 2. MARS1 expression in thyroid tissues with papillary thyroid cancer (PTC). Grade 2 and 3 expression in PTC cells, and grade 1 expression in normal thyroid follicular cells (magnification: 400×).

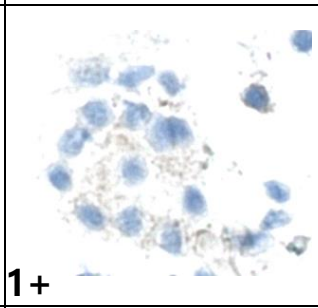
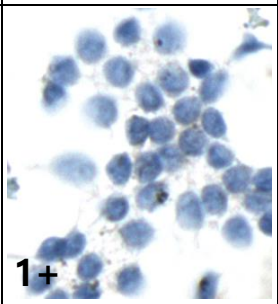
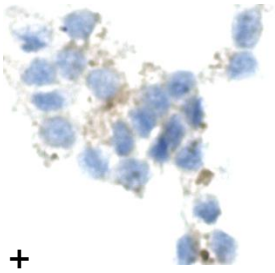
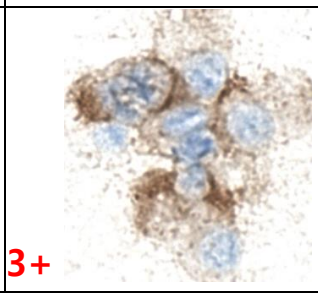
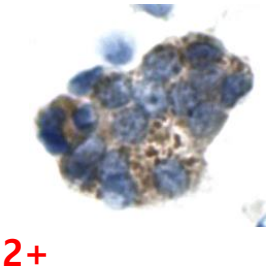
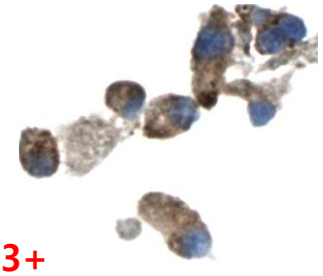
	Cytology Slide method / Antibody dilution factor		
	Smear 1:12800 MARS1 ICC grade	Surepath 1:20000 MARS1 ICC grade	Thin prep 1:20000 MARS1 ICC grade
Normal	 1+	 1+	 1+
Cancer	 3+	 2+	 3+

Figure 3. MARS1 expression in thyroid tissues with medullary thyroid cancer. Grade 2 and 3 expression in medullary thyroid carcinoma cells, and grade 1 expression in normal thyroid follicular cells (magnification: 400×).

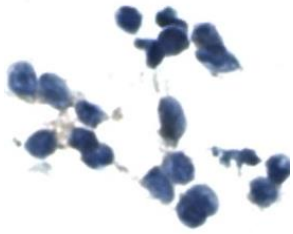
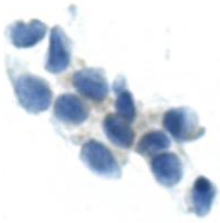
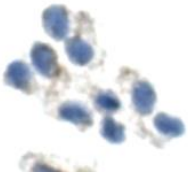
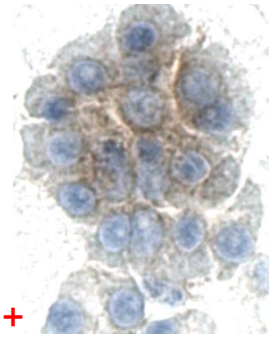
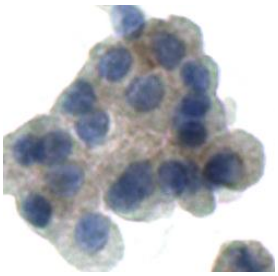
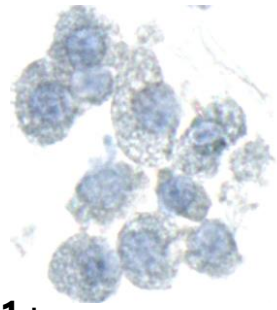
	Cytology Slide method / Antibody dilution factor		
	Smear 1:12800 MARS1 ICC grade	Surepath 1:15000 MARS1 ICC grade	Thin prep 1:15000 MARS1 ICC grade
Normal	 1+	 1+	 1+
Cancer	 2+	 2+	 1+

Figure 4. MARS1 expression in thyroid tissues with Hürthle cell adenoma Grade 2 expression in thyroid Hürthle cell adenoma, and grade 1 expression in normal thyroid follicular cells (magnification: 400×).

3.2. MARS1 expression, the possibility as a diagnostic tool for PTC

Normal and cancerous tissues were obtained from 103 patients, five of whom were excluded because the IHC evaluation results were unsuitable. The FNAB results obtained from 98 patients are listed in Table 1. In Table 1, malignancy in the final diagnosis included papillary thyroid cancer, medullary carcinoma, and Hürthle cell carcinoma. The conventional smear presente a sensitivity of 96.8%, specificity of 100%, positive predictive value of 100%, negative predictive value of 62.5%, and accuracy of 96.9%. MARS1 expression had a sensitivity of 98.9%, specificity of 20%, positive predictive value of 95.8%, negative predictive value of 50%, and accuracy of 94.9%. However, 93 t of the 98 patients (94.9%) exhibited malignancy in the final pathology results; therefore, the patient group itself was biased, and attention should be given to sensitivity and specificity.

Table 1. Correlation of cytologic assessment and MARS1 expression with the final pathology

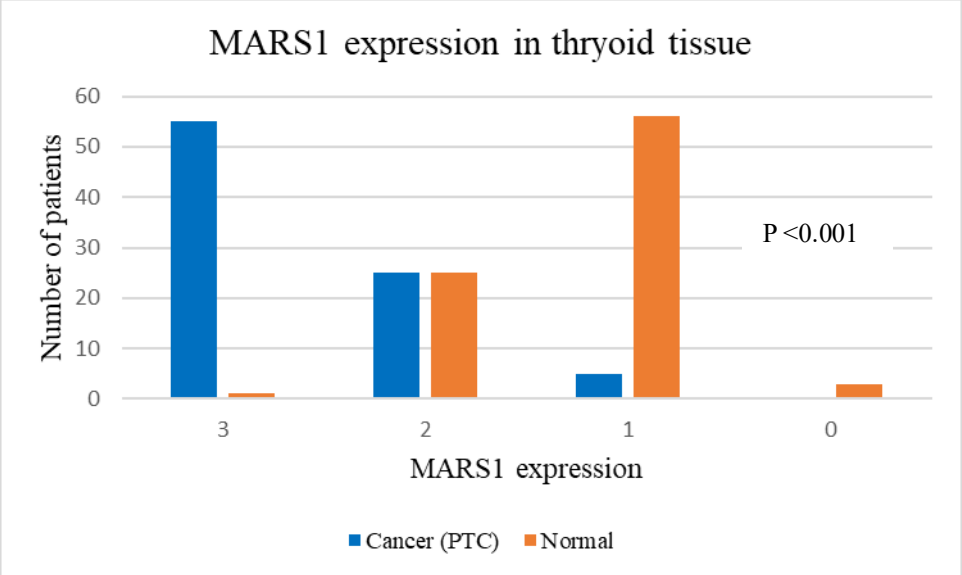
Conventional smear (TBSRTC)	MARS1 expression results	Final diagnosis	N= 98
Category 6 (n=55)	Positive: Grade 2,3	Malignancy	54
	Negative: Grade 1	Malignancy	1
Category 5	Positive: Grade 2,3	Malignancy	35
Category 3, 4 (n=6)	Positive: Grade 2,3	Malignancy	3
	Positive: Grade 2,3	Benign	3
Category 1,2 (n=2)	Positive: Grade 2,3	Benign	1
	Negative: Grade 1	Benign	1

3.3. MARS1 expression in normal follicular and PTC cells

Among the 103 patients, 85 presented with papillary thyroid cancer, after excluding those with damaged specimens, benign lesions, or other cancers. Table 2 presents the clinical features of the remaining 85 patients with papillary thyroid cancer. The number of female patients was 63 (74.1%), average age was 44.52 years, and average tumor size was 1.05 cm. Total thyroidectomy was performed in 34 patients, and the remaining 51 patients underwent partial thyroidectomy. Modified radical neck dissection (MRND) was performed in 11 patients, two of whom underwent bilateral MRND. The average number of harvested central lymph nodes was 5.33, and the average number of metastatic central lymph nodes was 1.82.

Table 2. Clinical features of 85 patients enrolled for determination of MARS1 expression in PTC

Parameter		**Values (n= 85)**	**%**
Age (mean, years)		44.52	
Gender	Male	22	25.9
	Female	63	74.1
Surgical extent	Total thyroidectomy	34	40
	Less than total thyroidectomy	51	60
LND	No	74	87.1
	Unilateral	9	10.6
	Bilateral	2	2.3
Thyroiditis		29	34.1
Extra-thyroidal lesion		9	7.1
Size (mean, cm)		1.05	
Positive central lymph node		1.82	
Total central lymph node		5.33	



MARS1 Expression	3	2	1	0	Total	Average
Cancer (PTC)	55	25	5	0	85	2.59
Normal	1	25	56	3	85	1.28

Figure 5. MARS1 expression in cells of 85 patients with thyroid cancer. Average expression grades of MARS1 (0, 1, 2, or 3) in papillary thyroid carcinoma (PTC) and normal follicular cells of 85 patients with PTC.

Figure 5 presents the comparison of MARS1 expression between PTC and normal follicular cells in thyroid tissues. Fifty-five patients exhibited Grade 3 PTC cell expression. Grade 2 expression was observed in 25 patients, and Grade 1 expression in five patients. None of the patients with PTC cells was categorized as having Grade 0 MARS1 expression. Fifty-six patients showed Grade 1 expression in normal follicular cells. Grade 2 expression was observed in 25 patients, and Grade 3 expression in only one patient. Three patients showed Grade 0 expression. The average MARS1 expression in PTC cells was 2.59 and that in normal follicular cells was 1.28, with the two groups exhibiting significant differences ($p<0.001$).

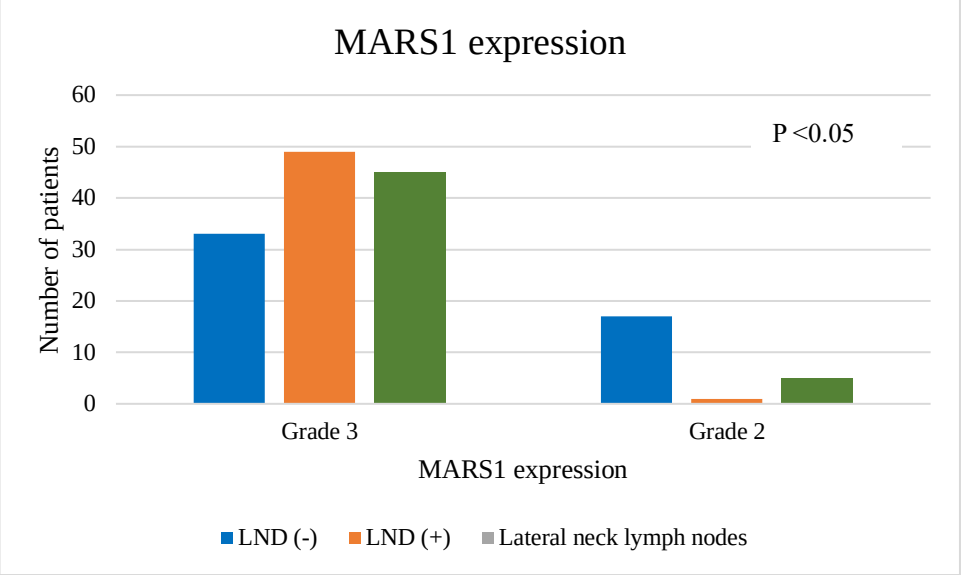
3.4. MARS1 expression with and without lateral neck node metastasis

One-hundred patients were selected to compare MARS1 expression between patients with those with (n = 50) and without (n = 50) lateral neck metastasis. Thyroid cancer tissues were obtained from stored tissue blocks of all patients, and lymph node tissues were obtained from patients with lateral neck metastasis. The clinical features of the enrolled patients are presented in Table 3.

Table 3. Clinical features of patients divided into LND (-) and LND (+) groups based on whether they underwent LND

Parameter		LND (-) N=50	LND (+) N=50	p-value
Age (Mean, years)		48.78	40.62	0.001
Gender	Male	10	10	
	Female	40	40	
Surgical extent	Total thyroidectomy	50	50	
LND	Unilateral		48	
	Bilateral		2	
Thyroiditis		20(10.0%)	25 (50%)	0.315
Extra thyroidal lesion		0	21 (42%)	<0.001
Calcification		18 (36%)	35(70%)_	<0.001
Size (mean, cm)		1.34	1.45	0.096
Positive central lymph node		1.38	4.14	0.000
Total central lymph node		7.20	8.18	0.376
Positive lateral lymph node		.	4.42	
BRAF mutation		28 (56%)	39(78%)	0.019
Recurrence		2 (4.0%)	6 (12.0%)	0.269

Each group comprised ten male and 40 female patients, and total thyroidectomy was performed in all patients. In the metastasis group, two patients underwent bilateral LND, whereas unilateral LND was performed in the remaining patients. The average age of each group was 48.78 and 40.62 years, respectively (p=0.001). The average tumor size was 1.45 cm in patients who underwent LND and 1.34 cm for the patients who did not undergo LND (p=0.096). The average number of harvested central lymph nodes was 7.20 and 8.18 (p=0.376), whereas those of the harvested metastatic central lymph nodes were 1.38 and 4.14 (p=0.000), in patients who did and did not undergo LND, respectively. The clinical follow-up period ranged from 79 to 108 months, and two 2 cases of recurrence were recorded in the group that underwent thyroidectomy without LND, and six cases in the group that underwent thyroidectomy with LND, and none of the patients died.



MARS1 expression	3	2	1	Total	Average
LND (-)	33	17	0	50	2.66
LND (+)	49	1	0	50	2.98
Lateral neck lymph nodes	45	5	0	50	2.90

Figure 6. MARS1 expression in groups with and without LND. Comparison of average MARS1 expression grades between patients with and without lateral neck metastasis.

Figure 6 shows a comparison of MARS1 expression between the lateral neck metastasis and no-metastasis groups. In the non-metastatic group, 33 patients showed grade 3 expression. Grade 2 expression was observed in 17 patients, and none of exhibited grade 1 expression. In the group with lateral neck metastasis, 49 patients showed grade 3 expression and only one patient showed grade 2 expression. In the group of patients with lateral neck lymph nodes, 45 patients showed grade 3 expression and five patients showed grade 2 expression. In the group without metastasis, the average MARS1 expression grade was 2.66 ± 0.479, and in patients with metastasis, the average was 2.98 ± 0.141. The average number of lymph nodes in patients with lateral neck metastasis was 2.90 ± 0.303. A significant difference in the average grade of MARS1 expression as observed in the PTC cells from the metastatic and non-metastatic groups ($p<0.05$). A significant difference was also observed in the average MARS1 expression grade between the lymph nodes of the metastatic group and the PTC cells of the non-metastatic group ($p<0.05$). No difference in the average MARS1 expression grade between lymph nodes and PTC cells was observed in the metastasis group ($p=0.94$).

3.5. MARS1 expression, the possibility as a prognostic factor in PTC recurrence

To determine whether MARS1 is as a prognostic factor in thyroid cancer, we assessed the recurrence rates of PTC in patients who underwent long-term follow-up. In Table 3, two cases of recurrence were observed in the group of patients who did not undergo LND, and six cased of recurrence were observed in the group of patients who underwent LND due to lateral neck node metastasis during the clinical follow-up period. The difference in the recurrence rates between the two groups was not statistically significant. ($p=0.269$) All recurrence sites occurred in operation bed, regional lymph nodes and lateral neck nodes, but no distant metastasis was observed.

Univariate analysis was performed to identify factors affecting recurrence, and only cancer size was shown to be associated with recurrence.($p<0.05$) (Table 4). MARS1 expression in PTC or the metastatic lymph nodes did not show a statistically significant relationship with cancer recurrence. MARS1 expression in PTC or metastatic lymph nodes was not a significant prognostic factor for recurrence. However, as shown in Figure 6, the proportion of PTC with high grade MARS1 expression significantly correlated with lateral neck node metastasis. Therefore, MARS1 expression is not a direct prognostic factor, but has potential as a prognostic factor because it exhibits a higher grade more often in cases with lateral neck node metastasis.

Table 4. Univariate and multivariate analysis of disease free survival for clinicopathological features of 100 patients with PTC

Variables	Univariate analysis			
	Exp(B)	95%CI		P-value
Age	1.006	0.949	1.066	0.847
Female gender	0.378	0.082	1.736	0.211
LND	0.306	0.059	1.594	0.159
Cancer size	15.212	1.476	156.735	*0.022*
Extra-thyroidal extension	4.412	1.002	19.430	0.050
Calcification	2.872	0.551	14.981	0.211
Thyroiditis	0.156	0.018	1.318	0.088
Positive central LN	1.142	0.984	1.325	0.081
Maximal LN size	2.319	0.867	6.200	0.094
BRAF mutation	3.733	0.440	31.692	0.227
PTC MARS1 expression	174647158.800	0.000	.	0.998
LN MARS1 expression	0.500	0.046	5.404	0.568
Variables	Multivariate analysis			
	Exp(B)	95%CI		P-value
Cancer size	11.406	1.035	125.680	*0.047*
Extra-thyroidal extension	3.177	0.676	14.926	0.143

4. DISCUSSION

Elevated MARS1 expression in carcinomas can be used to diagnose the malignancy of indeterminate specimens in several cancer types. The high sensitivity and accuracy of MARS1 immunofluorescence staining enable the detection of malignancies in patients with biliary strictures (11). Furthermore, high MARS1 expression in pancreatic ductal adenocarcinoma is associated with a poor prognosis [12]. In non-small-cell lung cancer (NSCLC), MARS1 staining has shown good diagnostic performance for determining lymph node metastasis [13]. MARS1 is also associated with a poor clinical prognosis in NSCLC [14]. In the present study, we determined that MARS1 play a similar role in PTC.

Average MARS1 expression was higher in PTC cells than in normal thyroid follicular cells. This can compensate for the limitation of conventional FNAB in the diagnosis of thyroid nodules. When

FNAB is performed to diagnose of thyroid nodules, TBSRTC is used to describe the FNAB results [3]. In this system, Categories 3 (atypia or undetermined) and 4 (follicular neoplasm) are not considered "confirmed cancer", but have possibility to be diagnosed as thyroid cancer at the permanent pathology. Therefore, when patients are diagnosed with Category 3 or 4 after FNAB, the surgical options cannot be excluded, and, in practice, thyroidectomy is often performed [15]. If the final pathology does not identify cancer, surgery is an unnecessary procedure that is performed to eliminate the possibility of cancer. Determining the MARS1 expression level has the potential to help avoid this unnecessary process. If the MARS1 expression grade with FNAB is high, surgery is a reasonable option. If the MARS1 expression grade with FNAB is low or similar to that in normal tissues, surgery can be postponed or avoided in favor of follow-up.

Another aim of this study was to test the hypothesis that MARS1 is a potential prognostic marker for thyroid cancer. Patients with lateral neck metastases showed a higher average MARS1 expression grade than those without lateral neck metastases. Considering that thyroid cancers with lateral neck metastasis are aggressive, higher MARS1 grade expression may be associated with more aggressive thyroid cancers. Further studies, including comparisons between groups and overall patient survival are required to elucidate the relationship between MARS1 expression and the prognosis of thyroid cancer.

This study has several limitations. First, this was a single-center study, and the study population was small. Second, we did not evaluate the actual diagnostic effectiveness of MARS1 in TBSTRC category 3 and 4. Additional studies on category 3 and 4 with MARS1 expression grades are required to determine the effectiveness of MARS1 expression as a diagnostic factor. Studies on the MARS1 expression grades are also required to determine the effectiveness of MARS1 expression as a prognostic factor.

5. CONCLUSION

The present study showed that MARS1 expression can be used as a complementary method to current FNAB tissue staining methods for cancer diagnosis. Furthermore, the average MARS1 expression in PTC and normal follicular cells was significantly different, reinforcing its potential as a diagnostic marker that can also predict prognosis in thyroid cancer cases.

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Abstract in Korean

Methionyl-tRNA 합성효소 1 (MARS1) 발현이 갑상선 유두암에서 진단 및 예후인자로써의 가능성에 관한 연구

Methionyl-tRNA synthetase 1 (MARS1)은 단백질 합성의 번역과정(translation)의 시작에 중요한 효소로, Met 을 개시 tRNA 로 전달하는 촉매 역할을 합니다. 최근 여러 암종에서 진단적 수단 및 예후 예측인자로써 MARS1 발현을 측정하는 연구가 있어왔습니다. 이 연구에서는 MARS1 발현이 갑상선 조직에서 어떻게 보이는지, 정상 모낭 세포와 갑상선유두암(PTC) 세포 간에 차이가 있는지를 알아보고자 하였습니다. 그리고 현재 PTC 진단을 위해 수행되는 일반적인 세포 염색 방법을 보완할수 있는지, 예후 예측인자로써 사용할 수 있는지 알아보는 것을 목표로 했습니다. 처음에 103 명의 환자에서 세침 흡입검사를 시행하여, 갑상선 암세포와 정상 갑상선 유두세포에서 MARS1 발현을 비교해 보았습니다. 다음으로 100 명의 환자의 보관된 조직에 면역조직화학 분석을 사용하여 측면 경부 전이가 있는 환자(n=50)와 없는 환자(n=50)에서 MARS1 발현을 비교하였습니다. 이 환자들의 임상적 추적기간에 재발여부에 따라 MARS1 발현에 차이가 있는지, 알아보았습니다. 갑상선 유두암 세포의 평균 MARS1 발현 등급은 2.59 였고 정상 갑상선 세포의 평균 MARS1 발현 등급은 1.28 이었습니다. 두 그룹의 MARS1 발현은 유의한 차이를 보였습니다 ($p<0.001$). 측경부 림프절 전이 그룹과 비전이 그룹 간에 갑상선 유두암 세포의 평균 MARS1 발현 등급에 유의한 차이가 있었습니다 ($p<0.05$). 또한 전이 그룹의 림프절과 비전이 그룹의 PTC 세포 간에 평균 MARS1 발현 등급에 유의한 차이가 관찰되었습니다 ($p<0.05$).

저희 분석은 MARS1 이 현재의 미세 바늘 흡인 생검 조직 염색 방법에 대한 추가적인 보완 방법으로 사용될 수 있음을 시사합니다. 또한 MARS1 은 갑상선 유두암의 재발의 직접적인 예후 예측 인자는 아니나, 갑상선 측경부 림프절 전이와 관련이 있어 진행성 갑상선암을 예측할 수 있는 가능성이 있습니다.

핵심되는 말 : MARS 1, 갑상선암, 갑상선유두암, 진단수단, 예후인자