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Prognostic Heterogeneity in Intermediate-Risk Papillary Thyroid Cancer: Surgery, Radioiodine, and Reclassification Using the 2025ATA Risk Stratification System

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Abstract

Background The 2015 American Thyroid Association (ATA) intermediate-risk category for papillary thyroid carcinoma (PTC) includes patients with heterogeneous outcomes, creating uncertainty regarding surgical extent and postoperative radioactive iodine (RAI). This study evaluated associations of surgical extent and RAI with structural recurrence-free survival (sRFS) and assessed prognostic stratification using the 2025 ATA system.

Methods We retrospectively analyzed 454 patients with PTC treated between January 2018 and December 2021 who met the 2015 ATA intermediate-risk criteria. Patients underwent lobectomy without RAI (n = 68), total thyroidectomy without RAI (n = 102), or total thyroidectomy followed by RAI (n = 284). One-to-one propensity score matching (PSM) was performed for lobectomy versus total thyroidectomy and for total thyroidectomy with versus without RAI. All patients were reclassified according to the 2025 ATA system.

Results After PSM, sRFS did not differ significantly between lobectomy and total thyroidectomy (P = 0.487) or between total thyroidectomy with and without RAI (P = 0.744). Reclassification assigned 1 patient (0.2%) to low risk, 123 (27.1%) to low-intermediate risk, 322 (70.9%) to intermediate-high risk, and 8 (1.8%) to high risk. Structural event rates were 0%, 12.2%, 17.4%, and 50.0%, respectively, with significant differences across strata (log-rank P = 0.039).

Conclusion The 2015 ATA intermediate-risk category showed substantial prognostic heterogeneity. Neither more extensive surgery nor postoperative RAI was associated with improved sRFS after PSM. The 2025 ATA system further separated this population into prognostically distinct groups, although treatment-specific benefits within these strata were not evaluated.

Keywords Papillary thyroid cancer, Intermediate risk, Radioactive iodine ablation, Thyroidectomy

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Papillary thyroid carcinoma (PTC) accounts for the majority of malignant thyroid tumors, and its incidence has risen progressively during recent decades (1). Despite generally favorable long-term outcomes, structural recurrence develops in a proportion of patients after primary treatment, necessitating further intervention and prolonged follow-up (2). Accurate estimation of recurrence risk is therefore central to postoperative management. In 2015, the American Thyroid Association (ATA) updated its recurrence-risk classification on the basis of clinicopathological features and divided patients into low-, intermediate-, and high-risk groups (3). Subsequent advances in the understanding of PTC biology and accumulating outcome data, however, have indicated that this three-tier framework does not fully capture variation in recurrence risk, particularly within the broad intermediate-risk category.

The role of postoperative radioactive iodine (RAI) therapy and the optimal extent of thyroid surgery remain uncertain in patients classified as intermediate risk under the 2015 ATA system. Although RAI is commonly considered for intermediate-risk disease, its potential benefit is unlikely to be uniform across this heterogeneous population. Recent studies have questioned whether routine RAI administration improves outcomes in all intermediate-risk patients (4). Total thyroidectomy facilitates postoperative thyroglobulin surveillance and subsequent RAI administration but may increase the risks of permanent hypoparathyroidism, recurrent laryngeal nerve injury, and other treatment-related morbidity. Lobectomy may reduce morbidity in appropriately selected patients, although its ability to provide comparable oncologic control in intermediate-risk disease remains uncertain. These uncertainties may partly reflect the broad range of clinicopathological features encompassed by the 2015 ATA intermediate-risk category, which groups patients with substantially different risks of structural disease recurrence. The 2025 ATA guidelines introduced a more granular, four-tier recurrence-risk system, allowing closer examination of prognostic heterogeneity within this previously broad intermediate-risk population (5).

Therefore, the study recruited patients who had been diagnosed with PTC classified as intermediate-risk using the 2015 ATA recurrence-risk stratification system. The objective of this research was to evaluate whether RAI ablation therapy or total thyroidectomy had any impact on structural recurrence-free survival (sRFS) among patients with PTC in this particular group. All patients in the sample were stratified based on the 2025 ATA risk-stratification system, and their outcomes were compared in the newly stratified groups. This study further evaluated whether the revised 2025 ATA framework could better differentiate the prognostic heterogeneity within the 2015 intermediate-risk population and provide real-world evidence to support more refined risk assessment and individualized treatment planning for patients with intermediate-risk PTC.

Materials and Methods

Study Population

This retrospective study included consecutive patients who underwent thyroidectomy at the First Hospital of Shanxi Medical University between January 2018 and December 2021 and had a postoperative pathological diagnosis of PTC. The inclusion criteria were as follows: (1) classification as intermediate risk according to the 2015 ATA guidelines; (2) initial total thyroidectomy or lobectomy performed at our hospital; (3) definitive postoperative pathological confirmation of PTC; and (4) availability of postoperative follow-up data for outcome assessment. The exclusion criteria were as follows: (1) prior thyroid-related surgery; (2) concurrent primary malignancies originating from other organs; (3) receipt of targeted therapy or external-beam radiation therapy; and (4) absence of valid postoperative follow-up records.

The study was approved by the Ethics Committee of the First Hospital of Shanxi Medical University (approval number 2026053). The requirement for informed consent was

waived because of the retrospective design and use of de-identified data. All procedures were conducted in accordance with the Declaration of Helsinki.

Study Variables

Demographic, clinical, imaging, pathological, treatment, and follow-up data were retrospectively extracted from the institutional electronic medical record and pathology systems. Demographic variables included age, sex, and body mass index (BMI). Preoperative clinical and imaging data included findings relevant to surgical planning and initial disease assessment. Treatment variables included the type of initial thyroid surgery and postoperative RAI administration. Pathological variables included maximum tumor diameter, tumor focality, laterality, microscopic extrathyroidal extension (ETE), lymph-node metastasis, number of positive lymph nodes, maximum diameter of the largest metastatic lymph node, and pN category according to the eighth edition of the American Joint Committee on Cancer (AJCC) TNM staging system. Follow-up data included postoperative neck ultrasonography, serum thyroglobulin (Tg) and antithyroglobulin antibody (TgAb) measurements, additional imaging when clinically indicated, and the occurrence and date of structural disease events. Patients were followed longitudinally after surgery, with follow-up data available through July 1, 2026. Patients without a documented structural disease event were censored at their most recent valid disease-free assessment.

Primary Endpoint

Structural recurrence was selected as the primary study outcome. An event was considered to have occurred when clinically relevant persistent or recurrent locoregional disease was demonstrated by imaging, recurrence or metastatic disease was verified histologically, or distant metastatic lesions were detected. sRFS was calculated from the date of surgery to the earliest confirmed structural recurrence. In patients who remained free of structural disease, survival time was censored at the most recent valid follow-up assessment.

Biochemical abnormalities alone, including increased thyroglobulin (Tg) concentrations or persistent antithyroglobulin antibody (TgAb) positivity without detectable structural disease, were not classified as endpoint events.

Group Assignment and Re-stratification According to the 2025 ATA Risk Guidelines

The stratification for the study population was done based on the type of surgery performed and the use of post-operative RAI. In Group A, the patients received a lobectomy without initial RAI. Group B comprised individuals who had undergone total thyroidectomy but did not receive any initial RAI. Group C included those patients who received total thyroidectomy with initial RAI treatment. For studying the prognostic difference among the intermediate-risk group identified earlier, all the subjects in the sample were now stratified into four risk groups using the 2025 ATA guidelines, which are: low risk, low-intermediate risk, intermediate-high risk, and high risk. The frequency of structural recurrence and sRFS were then evaluated across these strata to determine the prognostic discrimination and potential clinical value of the updated ATA system.

Statistical Analysis

All analyses were performed using IBM SPSS Statistics for Windows, version 27.0. No baseline, pathological, treatment, or follow-up variables had missing values; therefore, no imputation or other missing-data procedures were required. Continuous variables were summarized as mean ± SD and compared using one-way analysis of variance for three-group comparisons or independent-samples t tests for two-group comparisons. Categorical variables were reported as n (%) and compared using Pearson's χ^2 test. PSM was performed separately for Groups A versus B and Groups B versus C. Propensity scores were estimated by logistic regression with comparison-specific demographic, tumor, and nodal covariates shown in Tables 2 and 3. One-to-one nearest-neighbor matching was performed without replacement, using a caliper of 0.2 SD of the logit of the propensity score. Covariate balance was assessed

using SMDs, with |SMD| < 0.20 considered acceptable. Median follow-up was estimated using the reverse Kaplan-Meier method. sRFS was estimated using the Kaplan-Meier method and compared using the log-rank test. Cox proportional hazards models were used to estimate HRs and 95% CIs. Outcomes were also compared across the four 2025 ATA risk strata in the entire cohort. All tests were two-sided, with $P < 0.05$ considered statistically significant.

Results

Characteristics of the Overall Study Cohort

A total of 1,690 consecutive patients with histologically confirmed PTC who underwent thyroid surgery at our institution from January 2018 through December 2021 were initially screened in this single-center retrospective cohort. Application of the 2015 ATA recurrence-risk criteria identified 635 patients as having intermediate-risk disease. Following exclusion of patients who failed to meet the eligibility requirements, 454 patients remained for the final analysis (Figure 1). Mean age was 44.35 ± 12.08 years, and mean BMI was 24.70 ± 3.85 kg/m². The cohort included 323 women (71.1%) and 131 men (28.9%). Median follow-up was 58.65 months (95% CI, 57.55-59.74). Based on the initial surgical strategy and subsequent use of radioactive iodine (RAI), 68 patients were assigned to Group A (lobectomy without initial RAI), 102 to Group B (total thyroidectomy without initial RAI), and 284 to Group C (total thyroidectomy followed by initial RAI). Detailed clinicopathological features of the three treatment groups are presented in Table 1. Sex distribution and BMI were comparable among the three groups, with no significant between-group differences ($P > 0.05$). Structural events occurred in 10.3% of patients in Group A, 11.8% in Group B, and 19.7% in Group C. Despite the higher numerical frequency observed in Group C, the overall difference in structural event rates did not reach statistical significance ($P > 0.05$). In contrast, baseline clinicopathological profiles differed significantly with respect to patient age, primary tumor

size, laterality, lesion number, microscopic extrathyroidal extension (ETE), and the extent of lymph node involvement. Differences in nodal disease were reflected by the number of metastatic lymph nodes, the largest diameter of metastatic lymph nodes, and pN category. Among these variables, tumor laterality, lesion multiplicity, microscopic ETE, and measures of lymph node disease burden showed the strongest between-group differences ($P < 0.001$). These findings indicate substantial baseline imbalances in tumor and lymph node burden among the groups, underscoring the need for appropriate adjustment of baseline confounders in subsequent comparative analyses.

Survival Analysis Comparing Total Thyroidectomy with Lobectomy Following PSM

PSM for Groups A and B incorporated the prespecified covariates described in the Statistical Analysis section. Matching yielded 46 patients per group, with acceptable balance across all covariates (absolute SMDs < 0.20; Table 2).

Kaplan-Meier analysis (Figure 2) showed that the 3- and 5-year sRFS rates were 93.5% and 87.4%, respectively, in the lobectomy group and 93.4% and 93.4%, respectively, in the total thyroidectomy group. No significant difference in sRFS was observed between the two groups ($\chi^2 = 0.482$, $P = 0.487$). Using the total thyroidectomy group as the reference, univariate Cox proportional hazards regression yielded a HR of 1.652 (95% CI, 0.394-6.920; $P = 0.492$) for the lobectomy group, indicating no statistically significant difference. This result was consistent with the Kaplan-Meier analysis.

Survival Analysis Comparing PTC Patients With and Without Initial Postoperative RAI After Total Thyroidectomy Following PSM

PSM for Groups B and C incorporated the prespecified covariates described in the Statistical Analysis section. Matching yielded 52 patients per group, with acceptable balance across all covariates (absolute SMDs < 0.20; Table 3).

The 3- and 5-year sRFS rates after matching were 90.4% and 88.2%, respectively, in

Group B and 86.5% and 86.5%, respectively, in Group C. sRFS did not differ significantly between the groups (log-rank $\chi^2 = 0.106$, P = 0.744; Figure 3). Cox regression yielded an HR of 1.199 for Group C relative to Group B (95% CI, 0.403-3.566; P = 0.745).

Re-stratification According to the 2025 ATA Risk-Stratification System

When the 454 patients originally classified as intermediate risk according to the 2015 ATA criteria were re-stratified using the 2025 ATA risk-stratification system, 1 patient (0.2%) was reclassified as low risk, 123 (27.1%) as low-intermediate risk, 322 (70.9%) as intermediate-high risk, and 8 (1.8%) as high risk (Figure 4). The corresponding numbers of structural recurrence events were 0, 15, 56, and 4, respectively. The structural recurrence rate increased from 12.2% in the low-intermediate-risk group to 17.4% in the intermediate-high-risk group and reached 50.0% in the high-risk group (Table 4). Kaplan-Meier analysis demonstrated a statistically significant difference in sRFS across the four 2025 ATA risk strata (log-rank $\chi^2 = 8.390$, P = 0.039) (Figure 5). The 3- and 5-year sRFS rates were 89.2% (95% CI, 83.7%-94.7%) and 87.6% (95% CI, 81.3%-93.9%), respectively, in the low-intermediate-risk group; 88.7% (95% CI, 85.2%-92.2%) and 82.7% (95% CI, 78.2%-87.2%), respectively, in the intermediate-high-risk group; and 50.0% (95% CI, 15.3%-84.7%) in the high-risk group. Because only one patient was classified as low risk and no structural recurrence occurred in this patient, stable time-specific survival estimates were not reported for this group.

Discussion

Among the 454 patients classified as intermediate risk according to the 2015 ATA criteria, propensity-score-matched analyses showed no significant difference in sRFS between lobectomy and total thyroidectomy without RAI or between total thyroidectomy with and without postoperative RAI. Re-stratification of this original intermediate-risk cohort

according to the 2025 ATA system revealed a clear prognostic gradient.These findings demonstrate substantial prognostic heterogeneity within the intermediate-risk category defined by the 2015 ATA system.

This heterogeneity is particularly relevant to the ongoing controversy regarding the efficacy of RAI therapy. In the present study, after major clinicopathological characteristics were balanced by PSM, no significant difference in sRFS was observed between patients who did and did not receive postoperative RAI after total thyroidectomy. This finding suggests that postoperative RAI was not associated with significantly improved sRFS in a subset of intermediate-risk patients with adequate surgical resection and a relatively limited burden of adverse pathological features, consistent with the findings of several previous studies (6-10). Notably, after PSM, the Kaplan-Meier curve for the RAI group remained below that for the non-RAI group. However, the difference was not statistically significant, and the wide confidence interval precludes an inference of either benefit or harm associated with RAI in this cohort. Given the limited number of matched patients and structural disease events, these findings indicate an absence of an observed survival advantage rather than evidence against the therapeutic value of RAI. First of all, it does not mean that RAI does not have any therapeutic value for intermediate-risk patients. In 2015, in a study conducted using a big database, an effect of increased survival in patients undergoing RAI therapy was found (11), and a number of retrospective studies found that RAI decreases risk of recurrence in certain intermediate-risk patients (12-13). These favorable effects may largely reflect differences in tumor and lymph-node burden among the populations studied. The baseline characteristics of our cohort before PSM support this interpretation: patients who received RAI had more metastatic lymph nodes, larger metastatic lymph nodes, and a higher prevalence of N1b disease than those who did not receive RAI. Therefore, the poorer sRFS observed in the RAI group before matching likely reflects baseline risk differences related to treatment selection

rather than an adverse intrinsic effect of RAI.

A similar conclusion can be drawn from a comparison between total thyroidectomy and lobectomy. After PSM, sRFS did not differ significantly between the groups. In this selected intermediate-risk cohort, total thyroidectomy was not associated with a lower risk of structural disease events than lobectomy after matching, consistent with several recent studies (14-17). Clinically, lobectomy is usually preferred for patients with one-side tumors and low node involvement while rarely used for patients with both-side tumors and high node involvement or any other high-risk features (18). By its nature, the selection for a certain treatment method generates selection bias because lobectomy patients will be the most favorable group of intermediate-risk patients. A recent re-stratification study by Chen et al. similarly demonstrated that the specific composition of intermediate-risk features had a greater prognostic impact than the surgical approach itself (19).

The controversies surrounding both postoperative RAI administration and the extent of thyroidectomy are partly attributable to the structure of the 2015 ATA risk-stratification system, which groups factors with markedly different prognostic implications, including lymph-node burden and minimal ETE, within a single intermediate-risk category. Consequently, recurrence risk varies substantially within this category, limiting its utility as a uniform basis for clinical decision-making (4,20-24). Petranović Ovčariček et al. noted that a central limitation of the previous intermediate-risk category is its broad inclusion of heterogeneous tumor stages and histological variants (25). The 2025 ATA risk-stratification system was revised to address this limitation. By subdividing and reorganizing intermediate-risk features, the updated system introduces more refined low-intermediate- and intermediate-high-risk categories between the conventional low-, intermediate-, and high-risk strata. In our cohort, re-stratification resulted in 27.1% of patients originally classified as intermediate risk being reassigned to the low-intermediate-risk group, 70.9% to the

intermediate-high-risk group, and 1.8% to the high-risk group. The 5-year sRFS was 87.6% in the low-intermediate-risk group, decreased to 82.7% in the intermediate-high-risk group, and fell to 50.0% in the high-risk group, with clear separation of the survival curves across the revised risk categories. This graded prognostic pattern is supported by recent evidence. According to Moneta et al., 670 patients with PTC, who were previously categorized using the 2015 criteria set by the ATA, were reclassified using the 2025 criteria for ATA. It was found that the low-intermediate risk group, which was newly identified, had a risk of structural disease that was between the traditional low and intermediate risk categories. The above findings clearly show that the revised categorization is able to classify transition risk patients not captured in the previous system (26).

Clinically, the main value of the refined 2025 ATA classification in this study was its ability to distinguish prognostic risk within the population previously classified as intermediate risk. The low-intermediate-risk and intermediate-high-risk groups comprised most of the cohort but differed in their risks of structural disease events. The high-risk group, although small, had markedly lower sRFS. These findings suggest that patients classified as intermediate risk under the 2015 ATA system should not necessarily be considered prognostically homogeneous. However, this study does not establish whether any specific 2025 ATA risk category derives greater benefit from lobectomy, total thyroidectomy, or postoperative RAI. The revised categories should therefore be viewed primarily as a framework for more refined prognostic assessment in this cohort; their ability to guide treatment selection requires further validation.

This study has several limitations. First, it was a single-center retrospective cohort study. Although PSM was used to rigorously adjust for known confounders, residual confounding from unmeasured factors and treatment-selection bias could not be completely eliminated. Second, under the 2025 ATA stratification, only one patient was classified as low risk and

eight as high risk. The small number of patients and outcome events in these categories resulted in imprecise survival estimates with wide confidence intervals, underscoring the need for validation in larger cohorts. Third, the follow-up duration was relatively short. Given the indolent nature of PTC, longer follow-up is required to adequately assess long-term oncologic outcomes.

Conclusion

In conclusion, the 2025 ATA risk stratification system more clearly delineated prognostic heterogeneity within the 2015 ATA intermediate-risk category. Neither total thyroidectomy nor postoperative RAI was associated with improved sRFS after PSM in this cohort. Although the revised classification improved prognostic discrimination, these findings do not support selecting treatment on the basis of the initial risk category alone. Integrating the 2025 ATA classification with dynamic postoperative assessment incorporating thyroglobulin, antithyroglobulin antibodies, imaging findings, and molecular features may provide a more individualized basis for subsequent management. This strategy requires validation in larger multicenter cohorts with longer follow-up.

Declarations:

Ethics approval and consent to participate: The study was approved by the Ethics Committee of the First Hospital of Shanxi Medical University (approval number 2026053). The requirement for informed consent was waived because of the retrospective design and use of de-identified data. All procedures were conducted in accordance with the Declaration of Helsinki.

Consent for publication: Not applicable. All individual data were de-identified, and no identifiable individual information was included in this manuscript.

Data Availability: The datasets generated and analyzed during the current study are not publicly available and cannot be shared externally because of institutional data-protection policies, patient privacy requirements, and restrictions imposed by the institutional ethics committee.

Disclosures: All authors have nothing to declare.

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Author Contributions: Li designed the study, performed experiments, drafted, visualized and revised the manuscript; Wang and Wang X collected, curated and analyzed data; Guo conceived the study, supervised research and edited the manuscript; Wei and Lu provided guidance and optimized the manuscript. All authors approved the final manuscript.

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Figure Legends

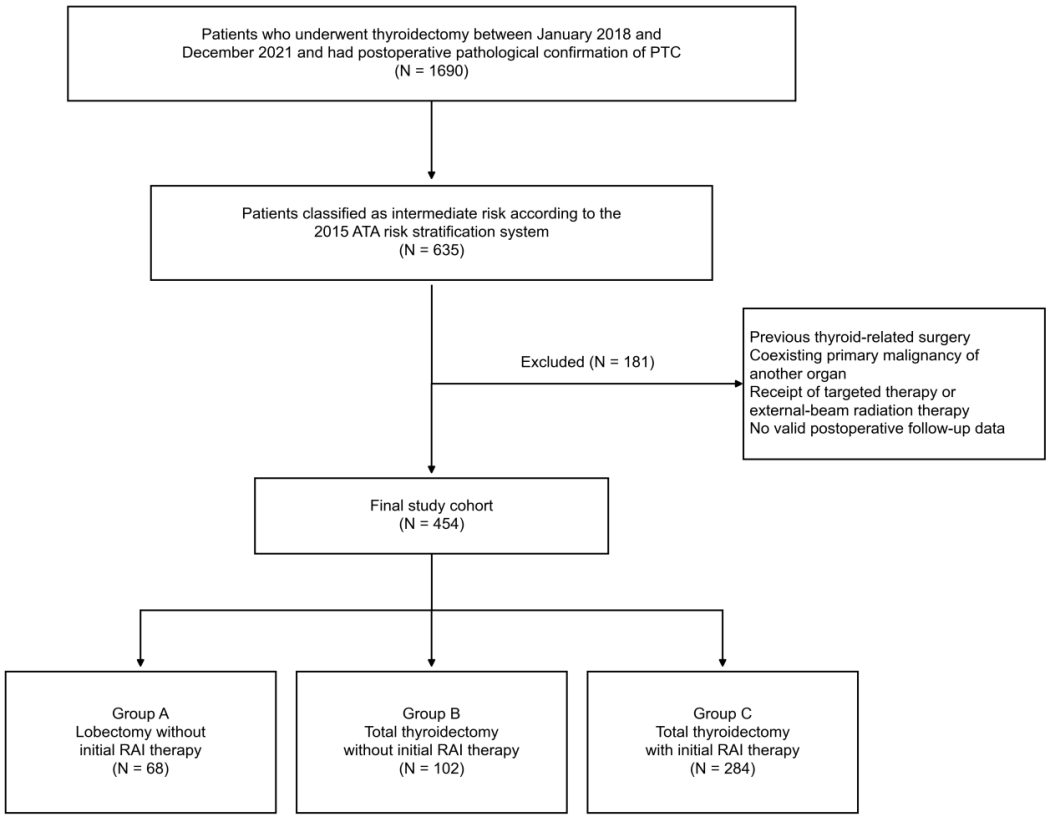


Figure 1. Patient selection flowchart.ATA, American Thyroid Association; PTC, papillary thyroid carcinoma.

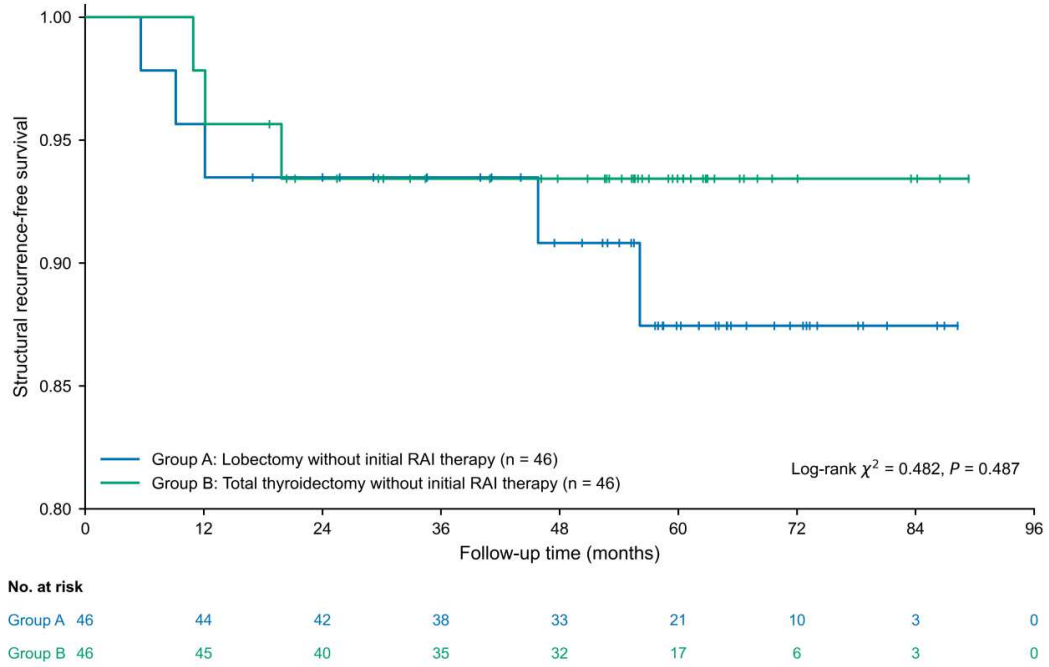


Figure 2. Kaplan-Meier curves for sRFS by surgical extent after PSM.PSM, propensity score matching; sRFS, structural recurrence-free survival.

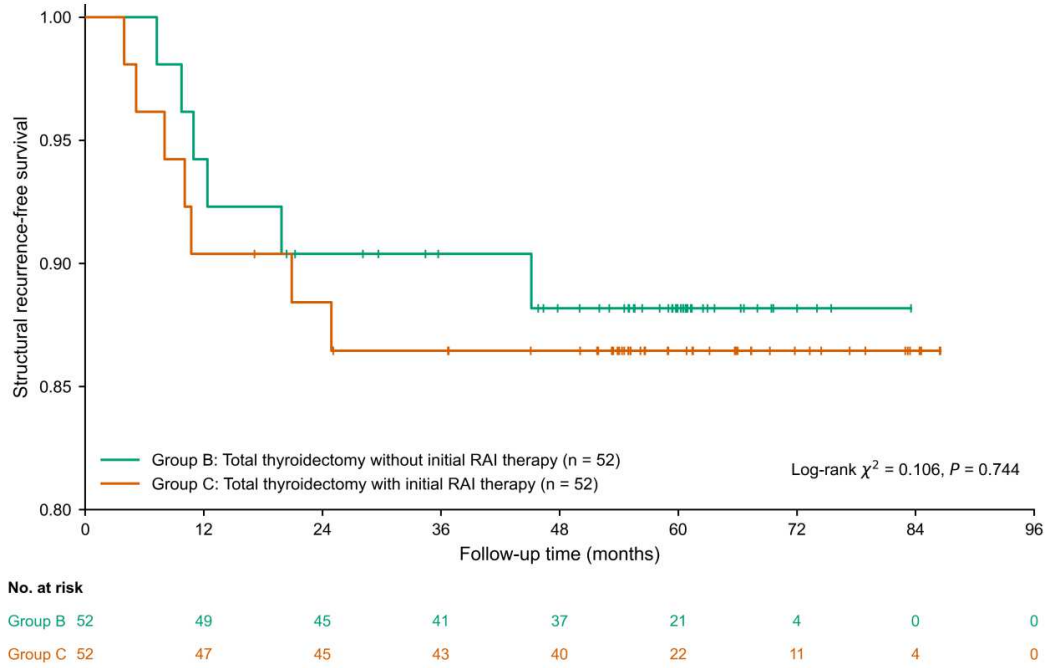


Figure 3. Kaplan-Meier curves for sRFS by initial postoperative RAI use after PSM in patients undergoing total thyroidectomy.PSM, propensity score matching; RAI, radioactive iodine; sRFS, structural recurrence-free survival.

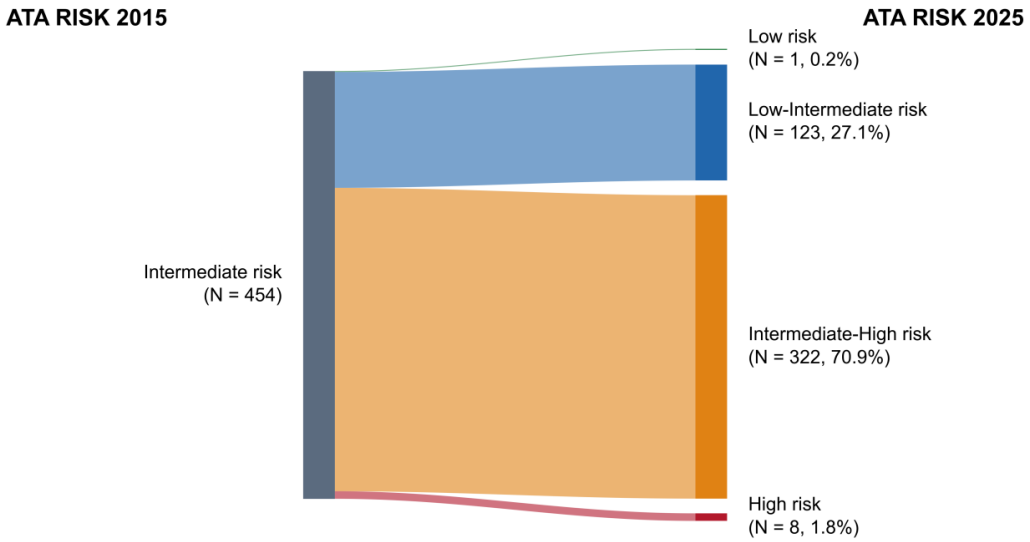
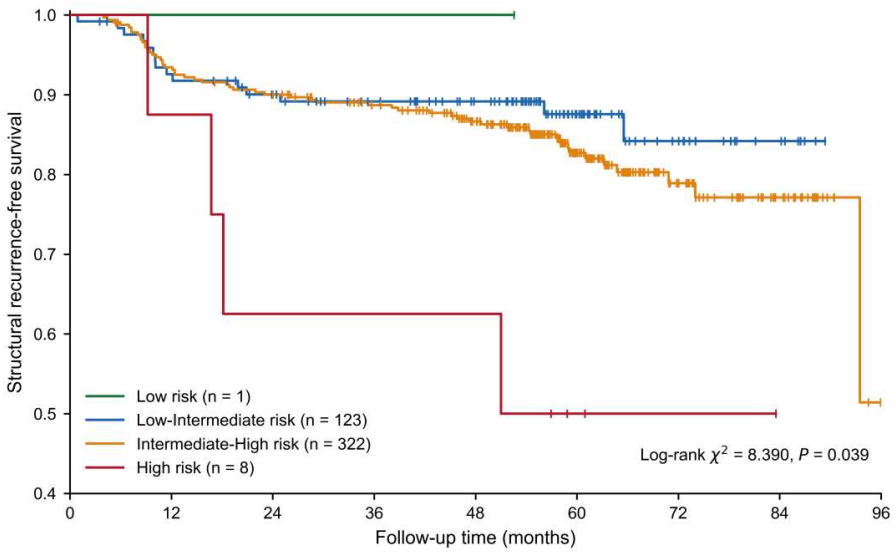


Figure 4. Sankey diagram showing the redistribution of patients originally classified as intermediate risk according to the 2015 ATA system across the 2025 ATA risk strata.



No. at risk

Low risk	1	1	1	1	1	0	0	0	0
Low-Intermediate risk	123	112	103	93	81	43	19	8	0
Intermediate-High risk	322	299	287	269	240	123	53	21	0
High risk	8	7	5	5	5	2	1	0	0

Figure 5. Kaplan-Meier curves of sRFS across the four-tier 2025 ATA risk categories.

441 **Table Legends**

442 **Table 1.** Baseline clinicopathological characteristics of intermediate-risk PTC patients in the

443 overall cohort

Characteristic	Total	A:Lobectomy (n=68)	B:TTwithoutRAI (n=102)	C:TT+RAI (n=284)	P value
Age,years	44.35±12.08	41.49 ± 12.12	47.21 ± 11.23	44.01 ± 12.19	0.007
SEX					0.174
Male	131 (28.9%)	20 (29.4%)	22 (21.6%)	89 (31.3%)	
Female	323 (71.1%)	48 (70.6%)	80 (78.4%)	195 (68.7%)	
BMI,kg/m^2	24.70±3.85	24.53 ± 3.75	25.01 ± 3.91	24.63 ± 3.86	0.638
Tumor size, cm	1.23±0.75	1.01 ± 0.64	1.14 ± 0.67	1.32 ± 0.79	0.003
Laterality					<0.001
Unilateral	295 (65.0%)	68 (100.0%)	64 (62.7%)	163 (57.4%)	
Bilateral	159 (35.0%)	0 (0.0%)	38 (37.3%)	121 (42.6%)	
Focality					<0.001
Unifocal	338 (74.4%)	64 (94.1%)	64 (62.7%)	210 (73.9%)	
Multifocal	116 (25.6%)	4 (5.9%)	38 (37.3%)	74 (26.1%)	
Microscopic ETE					<0.001
Absent	365 (80.4%)	49 (72.1%)	68 (66.7%)	248 (87.3%)	
Present	89 (19.6%)	19 (27.9%)	34 (33.3%)	36 (12.7%)	
positive_nodes,n	8.39±7.38	3.93 ± 3.10	3.66 ± 3.91	11.15 ± 7.68	<0.001
Largest metastatic node,cm	0.96±0.63	0.73 ± 0.45	0.62 ± 0.54	1.13 ± 0.64	<0.001
pN					<0.001

Characteristic	Total	A:Lobectomy (n=68)	B:TTwithoutRAI (n=102)	C:TT+RAI (n=284)	P value
N0	32 (7.0%)	8 (11.8%)	23 (22.5%)	1 (0.4%)	
N1a	141 (31.1%)	54 (79.4%)	53 (52.0%)	34 (12.0%)	
N1b	281 (61.9%)	6 (8.8%)	26 (25.5%)	249 (87.7%)	
Structural disease event					0.058
Absent	379 (83.5%)	61 (89.7%)	90 (88.2%)	228 (80.3%)	
Present	75 (16.5%)	7 (10.3%)	12 (11.8%)	56 (19.7%)	

444 **Note:** Data are mean +/- SD or n (%). Abbreviations: BMI, body mass index; ETE,
445 extrathyroidal extension; pN, pathological nodal category; RAI, radioactive iodine; SD,
446 standard deviation; TT, total thyroidectomy.

447

448 **Table 2.** Clinicopathological characteristics of the lobectomy and total thyroidectomy groups
449 after PSM.

Characteristic	A:Lobectomy (n=46)	B:Total thyroidectomy (n=46)	SMD	P value
Age, years	44.33 ± 12.93	42.78 ± 11.42	0.127	0.545
Tumor size, cm	1.01 ± 0.62	1.12 ± 0.71	0.160	0.444
Positive lymph nodes, n	3.65 ± 3.01	3.67 ± 3.71	0.006	0.975
Largest metastatic node, cm	0.68 ± 0.46	0.60 ± 0.54	0.174	0.407
Female sex	34 (73.9%)	35 (76.1%)	0.050	0.810
Multifocal disease	4 (8.7%)	3 (6.5%)	0.082	0.694
Microscopic ETE	12 (26.1%)	12 (26.1%)	0.000	1.000
pN0 / pN1a / pN1b	8 / 32 / 6	10 / 31 / 5	0.120	0.848

450 **Note:** Data are mean +/- SD or n (%). Abbreviations: ETE, extrathyroidal extension; pN,
451 pathological nodal category; SD, standard deviation; SMD, standardized mean difference.
452

453 **Table 3.** Clinicopathological characteristics of patients with and without RAI therapy after
454 total thyroidectomy following PSM.

Characteristic	B:TT without RAI (n=52)	C:TT + RAI (n=52)	SMD	P value
Age, years	45.81 ± 11.38	47.06 ± 12.45	0.105	0.594
Tumor size, cm	1.13 ± 0.71	1.17 ± 0.65	0.065	0.742
Positive lymph nodes, n	5.77 ± 4.30	6.29 ± 4.43	0.119	0.546
Largest metastatic node, cm	0.86 ± 0.56	0.82 ± 0.42	0.085	0.665
Female sex	38 (73.1%)	37 (71.2%)	0.043	0.827
Bilateral tumors	22 (42.3%)	23 (44.2%)	0.039	0.843
Multifocal disease	16 (30.8%)	18 (34.6%)	0.082	0.676
Microscopic ETE	8 (15.4%)	7 (13.5%)	0.055	0.780
pN0 / pN1a / pN1b	1 / 25 / 26	1 / 25 / 26	0.000	1.000

455 **Note:** Data are mean +/- SD or n (%). Abbreviations: ETE, extrathyroidal extension; pN,
456 pathological nodal category; RAI, radioactive iodine; SD, standard deviation; SMD,
457 standardized mean difference; TT, total thyroidectomy.

458

459 **Table 4.** Structural outcomes after re-stratification according to the 2025 ATA risk criteria.

460 NE, not estimated.

2025 ATA category	Patients, n (%)	Events, n	Event rate, %	3-year sRFS, % (95% CI)	5-year sRFS, % (95% CI)
Low	1 (0.2)	0	0.0	NE	NE
Low-intermediate	123 (27.1)	15	12.2	89.2 (83.7-94.7)	87.6 (81.3-93.9)
Intermediate-high	322 (70.9)	56	17.4	88.7 (85.2-92.2)	82.7 (78.2-87.2)
High	8 (1.8)	4	50.0	50.0 (15.3-84.7)	50.0 (15.3-84.7)

461 **Abbreviations:** ATA, American Thyroid Association; CI, confidence interval; NE, not

462 estimated; sRFS, structural recurrence-free survival.