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Research Article

Efficacy of Robot-Assisted Thyroidectomy via Unilateral Axillo-Unilateral Breast Approach: A Retrospective Propensity Score-Matched Study

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ABSTRACT

Purpose: This study aims to evaluate the safety, efficacy, and impact on patient-reported outcomes of the unilateral axillo-unilateral breast (UAUB) approach for robotic thyroidectomy in patients with thyroid carcinoma (TC), and to compare its performance with conventional open thyroidectomy (OT) and the bilateral axillo-breast approach (BABA) for robotic thyroidectomy.

Methods: This retrospective study included patients with unilateral papillary TC (PTC) who underwent thyroidectomy using the UAUB, OT, or BABA approaches at our center. To minimize baseline differences among groups, propensity score matching (PSM) was applied. Comparative analyses were conducted on perioperative outcomes, extent of lymph node dissection, postoperative recovery metrics, complication rates, and patient-reported outcomes.

Results: After PSM, baseline characteristics were balanced across the three groups. Compared to the OT group, the UAUB group exhibited longer operative times but significantly reduced intraoperative blood loss ($P < 0.001$), a higher rate of parathyroid autotransplantation ($P = 0.035$), and comparable overall complication rates. Additionally, patients in the UAUB group reported significantly greater satisfaction with cosmetic outcomes, improved postoperative quality of life, and decreased scar-related self-consciousness (all $P < 0.05$). When compared to the BABA group, the UAUB group showed reduced intraoperative bleeding and postoperative drainage volumes ($P < 0.05$), alongside superior cosmetic satisfaction and lower scar concern scores (both $P < 0.05$). Overall, the UAUB approach demonstrated favorable safety and oncologic efficacy while significantly enhancing patient satisfaction.

Conclusion: The UAUB approach is a safe, minimally invasive, and cosmetically superior surgical technique that delivers effective oncologic outcomes while enhancing postoperative comfort and aesthetic satisfaction. It represents a valuable alternative to conventional OT and other robotic approaches.

1. Introduction

In recent years, the incidence of thyroid carcinoma (TC) has steadily increased, becoming one of the fastest-growing solid malignancies worldwide, with a notable shift toward younger age at diagnosis and a predominance among female patients [1]. As a result, greater emphasis has been placed on postoperative aesthetic outcomes, quality of life, and the restoration of social functioning [2]. While conventional open thyroidectomy (OT) remains widely used due to its procedural maturity and accessibility, the anterior cervical incision often leaves visible scars that can adversely affect cosmetic appearance. This issue is especially significant for young female patients, for whom such scarring may cause psychological distress and a consequent decline in quality of life [3]. Robotic-assisted thyroidectomy has gained increasing acceptance due to

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its advantages, including high-definition three-dimensional visualization, improved instrument dexterity, and superior cosmetic results [4]. Consequently, various remote-access approaches have been developed to avoid visible cervical scars, such as the bilateral axillo-breast approach (BABA), transaxillary approach (TAA), transoral vestibular approach (TORT), and unilateral axillo-bilateral areolar approach (UAUBA), among others [5].

To further optimize surgical access, minimize trauma associated with working space creation, and preserve anterior cervical function, our center pioneered the use of the UAUB approach in robotic thyroidectomy and has since accumulated substantial clinical experience. This study details the surgical technique based on our institutional practice, emphasizing key modifications such as the addition of auxiliary ports to enhance intraluminal traction and tissue retraction. These improvements facilitate better operative field exposure, enable more effective access to the central compartment and lower cervical lymph nodes, and contribute to increased stability of the operative cavity and enhanced surgical maneuverability. Furthermore, by retrospectively comparing patients with papillary TC (PTC) who underwent robotic thyroidectomy via the UAUB approach with those treated by conventional OT or the bilateral BABA during the same period, we systematically evaluated differences in perioperative outcomes, surgical safety, and patient-reported experiences. The objective was to provide robust, evidence-based guidance for individualized surgical approach selection and to support the development of more precise treatment strategies in clinical practice.

2. Materials and Methods

2.1. Patient Characteristics

Baseline data were collected from 371 patients who underwent radical surgery for unilateral PTC using the UAUB, BABA, or OT approaches between January 2024 and January 2025 at the First Affiliated Hospital of Nanjing Medical University. All procedures were performed by a single experienced surgeon certified in robotic surgery, minimizing inter-operator variability. The study protocol was approved by the Institutional Ethics Committee (Approval No. 2025-SR-495).

2.2. Patient Enrollment

Patients were eligible for inclusion if they met all of the following criteria: (1) age ≥18 years; (2) histopathologically confirmed PTC; (3) tumor confined to a single thyroid lobe; (4) underwent unilateral thyroid lobectomy with isthmusectomy and ipsilateral central lymph node dissection; (5) preoperative lymph node staging classified as cN0 or cN1a [6]; and (6) complete clinical data and postoperative follow-up information available. Exclusion criteria included: (1) non-PTC histology, such as follicular, anaplastic, or medullary TC; (2) multifocal bilateral thyroid involvement or indication for total thyroidectomy; (3) radiological or intraoperative evidence of lateral neck lymph node metastasis necessitating modified radical neck dissection; (4) history of prior neck surgery or radiotherapy; (5) presence of cervical or thoracic deformities, severe cardiopulmonary dysfunction, or contraindications to general anesthesia; and (6) incomplete clinical records or missing follow-up data.

Based on these criteria, a total of 371 eligible patients were identified. In accordance with the study design, two sets of comparisons were conducted:

Robotic UAUB vs. OT: Among eligible patients, 36 underwent robotic UAUB and 275 underwent conventional OT. Propensity score matching (PSM) was applied at a 1:3 ratio, resulting in 30 matched UAUB cases and 90 matched OT cases for comparative analysis.

Robotic UAUB vs. Robotic BABA: Within the 36 UAUB patients, 60 patients who underwent robotic BABA thyroidectomy were identified. PSM was conducted at a 1:1 ratio, producing 32 matched pairs in each group, which were included in the final analysis.

2.3. Matching Method and Observation Index

PSM was employed to reduce baseline confounding between groups [7]. Matching was performed using key covariates including age, sex, tumor size (maximum diameter), body mass index (BMI), and presence of Hashimoto’s thyroiditis (HT). Following matching, perioperative and postoperative outcomes were compared, including intraoperative blood loss, operative time, number of lymph nodes dissected, number of metastatic lymph nodes, postoperative drainage volume, duration of drainage, length of hospital stay, 24-hour postoperative pain score, complication rate [8, 9], rate of parathyroid autotransplantation, and patient-reported aesthetic perception. Complication definitions were adopted from a previously published study [10]. To evaluate patient experience, validated questionnaires assessing cosmetic satisfaction, scar-related self-consciousness, and quality of life were administered three months postoperatively. The cosmetic satisfaction scale [11] and scar self-concern scale [12] were scored from 0 to 3, with higher scores indicating greater satisfaction or concern, respectively. Quality of life was assessed using a modified postoperative patient experience scale derived from the literature [13], with scores ranging from 1 to 4, where higher scores denoted greater impairment in quality of life. The full questionnaire is provided as a supplementary appendix (Appendix 1).

2.4. The UAUB Approach

2.4.1. Position

The patient was positioned supine with a shoulder roll to extend the neck and the head rotated approximately 45° toward the contralateral side. The ipsilateral upper limb was abducted about 30°. Planned incision sites and working space boundaries were marked on the skin surface, followed by routine disinfection and sterile draping.

2.4.2. Incision Selection

Four skin incisions, each approximately 1 cm in length and aligned with natural skin creases, were made for this approach. On the right side: Incision 1 was located at the apex of the axilla; Incision 3 was placed at the 11 o’clock position of the areola; Incision 2 was made midway between Incisions 1 and 3 along the anterior axillary line; and Incision 4 was positioned about 4 cm medial to Incision 3 (Figure 1A). For left-sided procedures, the incision layout was mirrored accordingly (Figure 1B). The auxiliary robotic arm was introduced through Incision 4, the two primary working arms through Incisions 1 and 3, and the endoscopic camera through Incision 2. Incision sites were slightly adjusted based on individual patient factors such as sex, body habitus, BMI, breast gland distribution, and areolar size:

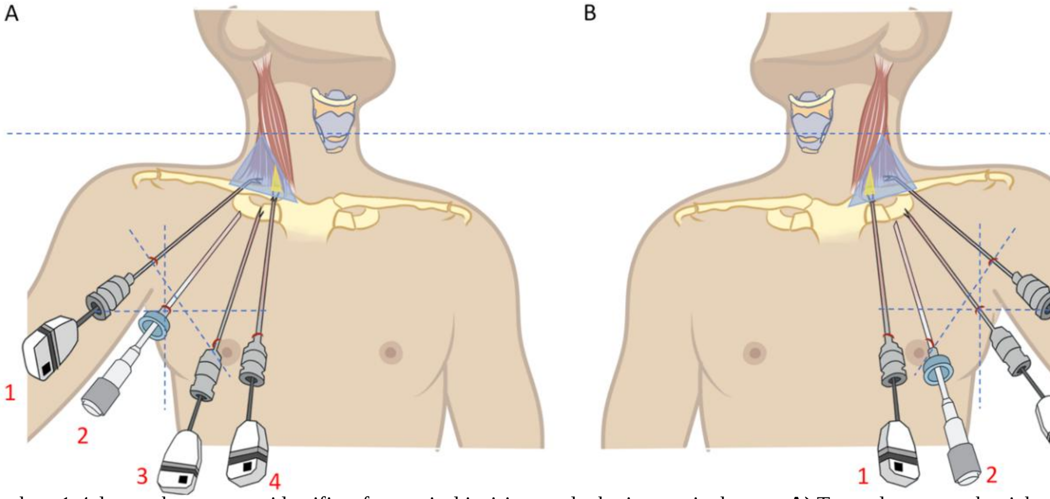

Fig. 1. Numbers 1-4 denote the sequence identifiers for surgical incisions and robotic arms in the text. **A)** Tumor locates on the right side. **B)** Tumor locates on the left side.

Step 1: Establishment of Initial Working Space
Following the skin incisions, approximately 5 mL of tumescent solution was injected into each subcutaneous tunnel. A blunt dissector was then used to gently separate the subcutaneous tissue and create the working channels. Trocars were inserted sequentially, and excess fluid was aspirated. CO_2 insufflation was initiated to establish a stable gas cavity, maintaining pressure between 6 and 8 mmHg. All robotic arms, except the auxiliary arm, were connected, and surgical instruments were introduced.

Step 2: Establishment of Stable Working Space
Under endoscopic guidance, the subplatysmal flap was elevated toward the intermuscular triangle, bounded by the sternal head and clavicular head of the sternocleidomastoid muscle and the clavicle, to establish a stable operative space. The dissection extended superiorly to the inferior margin of the thyroid cartilage; laterally beyond the lateral border of the ipsilateral sternocleidomastoid muscle; medially to the lateral border of the sternal head, exposing the sternoclavicular joint or muscle insertion; and inferiorly to the level of the clavicle. The auxiliary robotic arm (Arm 4) was connected and used to insert a pericardial grasper to retract the sternal head of the sternocleidomastoid muscle anterosuperiorly, thereby fully exposing the intermuscular triangle.

Step 3: Lateral Approach to Thyroid Exposure
The intermuscular space between the sternal and clavicular heads of the sternocleidomastoid muscle was dissected to expose the omohyoid and strap muscles laterally, along with the carotid sheath. The auxiliary arm was then repositioned to retract the strap muscles anterosuperiorly, providing clear visualization of the lateral aspect of the thyroid gland.

Step 4: Identification and Full Exposure of the Recurrent Laryngeal Nerve (RLN)
The middle thyroid vein was ligated and divided, and the thyroid gland was gently retracted anterosuperiorly. The RLN was first identified in the central neck region, inferior to the thyroid lobe. A tunnel-like dissection was then performed along the nerve's course, allowing full exposure up to its entry into the larynx.

Step 5: Central Neck Lymph Node Dissection
The lateral aspect of the strap muscles was partially divided to ensure adequate exposure of the lowermost central compartment. The inferior parathyroid gland was identified and carefully preserved using fine dissection along the thyrothymic ligament; if preservation in situ was not feasible, parathyroid autotransplantation was performed. Lymphatic and fatty tissues within the central compartment were dissected systematically from inferior to superior and lateral to medial. On the right side, routine dissection included lymph nodes located deep to the RLN.

Step 6: Thyroid Lobectomy
The upper pole of the thyroid was addressed first. Dissection proceeded along the thyroid capsule near the laryngeal entry point of the RLN, with careful efforts to preserve the superior parathyroid gland in situ. The gland was gently retracted inferiorly, and the cricothyroid space was dissected to expose the superior thyroid vessels, which were ligated close to the gland surface while protecting the external branch of the superior laryngeal nerve. The thyroid was further retracted medially and superiorly to expose and divide the suspensory ligament. Subsequently, the isthmus was dissected along the anterior tracheal space toward the contralateral tracheal border and divided in an inferior-to-superior direction.

Step 7: Prelaryngeal Lymph Node Dissection and Cavity Closure
The patient's head was slightly repositioned to the midline. The strap muscles overlying the anterior larynx were retracted superiorly using the auxiliary robotic arm, exposing the cricothyroid muscles bilaterally. Prelaryngeal lymph node dissection was then performed. Upon completion of the lymphadenectomy, the surgical field was irrigated, hemostasis ensured, and the operative cavity was closed in the standard fashion.

2.5. Conventional Open Surgery (OT group)

Using a conventional anterior neck transverse incision, unilateral thyroid lobectomy and isthmus resection combined with ipsilateral central lymph node dissection were performed under direct vision [14, 15] by experienced surgeons, following current clinical standard protocols.

2.6. BABA Robotic Surgery (BABA Group)

The operating cavity was established through four incisions located in the bilateral axilla and bilateral areola, and the da Vinci Xi Surgical System was utilized to perform gland removal and central compartment lymph node dissection. This procedure is routinely performed at our center, with a well-established and mature technical approach that has been widely applied across multiple indications [16].

2.7. Statistical Analysis

All statistical analyses in this study were performed using IBM SPSS Statistics version 26.0 and R software (version 4.3.1) [17]. Descriptive statistics summarized patients' baseline clinical characteristics and perioperative variables. Categorical variables were presented as frequencies and percentages, with intergroup comparisons conducted using the chi-square test or Fisher's exact test, as appropriate. Continuous variables were assessed for normality using the Shapiro–Wilk test; regardless of distribution, results were uniformly reported as mean ± standard deviation (M ± SD) for consistency and readability. Group comparisons were performed using the independent samples t-test for normally distributed data or the Mann–Whitney U test for non-normally distributed data.

To control for baseline imbalances and reduce potential confounding bias, PSM was employed to create balanced comparison cohorts. The matching procedure was performed using the "MatchIt" package in R, incorporating variables potentially associated with outcomes, including age, sex, BMI, tumor size, and presence of HT. A 1:3 nearest-neighbor matching algorithm with a fixed caliper width of 0.3 was applied for comparisons between the UAUB and OT groups, while a 1:1 nearest-neighbor matching was used for the UAUB and BABA groups. All statistical tests were two-tailed, with a p-value of <0.05 considered indicative of statistical significance.

3. Results

3.1. PSM Analysis Results

To minimize the influence of confounding factors on intergroup comparison results, PSM was conducted separately for the UAUB versus OT groups and the UAUB versus BABA groups.

3.1.1. UAUB Approach vs OT

A total of 36 patients in the UAUB group and 275 patients in the OT group were included prior to matching. Before PSM, a significant difference in age was observed between the two groups (34.1 ± 7.79 years vs. 44.78 ± 11.22 years, $P < 0.001$), while no statistically significant differences were noted in other baseline variables, including sex, BMI, presence of HT, or tumor size ($P > 0.05$). Following 1:3 nearest-neighbor matching, 30 UAUB patients were successfully matched with 90 OT patients. Post-matching analysis revealed no significant differences in baseline characteristics between groups, including age (34.53 ± 6.21 vs. 35.83 ± 6.35, $P = 0.272$), sex, BMI, HT status, and tumor size, confirming the effectiveness of the matching process (Table 1).

Table. 1. Comparison of the baseline characteristics between the UAUB group and OT group.

Variables	**Before PSM**			**After PSM**		
	UAUB (n=36)	**OT (n=275)**	**P**	**UAUB(n=30)**	**OT(n=90)**	**P**
age[a]	34.14±7.79	44.78±11.22	**<0.001**	34.53±6.21	35.83±6.35	0.272
sex[b]			0.371			0.618
male	9(0.25)	89(0.32)		8(0.27)	20(0.22)	
female	27(0.75)	186(0.68)		22(0.73)	70(0.78)	
BMI[a]	24.03±3.34	24.26±3.36	0.837	24.26±3.53	24.37±3.57	0.923
HT[b]	7(0.19)	55(0.2)	0.937	5(0.17)	25(0.28)	0.268
tumor size(mm)[a]	7.39±2.65	8.90±6.71	0.167	7.17±2.39	7.98±3.42	0.218

Statistical significance P < 0.05 values are in bold.

[a] Mann–Whitney U test was used.

[b] χ^2 test was used.

3.1.2. Robotic UAUB Approach vs Robotic BABA

A total of 36 patients in the UAUB group and 60 patients in the BABA group were included before matching. Prior to PSM, a significant difference in tumor size was observed between the two groups (7.39 ± 2.65 mm vs. 11.28 ± 7.63 mm, $P = 0.005$), whereas no statistically significant differences were found in other variables, including age, sex, BMI, and presence of HT. Following 1:1 nearest-neighbor matching, 32 patients were included in each group. Post-matching analysis showed no significant differences in baseline characteristics between the two groups, including age, sex distribution, BMI, HT status, and tumor size (7.69 ± 2.66 mm vs. 7.31 ± 3.60 mm, $P = 0.375$), indicating that the groups were well balanced and comparable (Table 2).

Table. 2. Comparison of the baseline characteristics between the UAUB group and BABA group.

Variables	Before PSM			After PSM		
	UAUB (n=36)	BABA (n=60)	P	UAUB(n=32)	BABA(n=32)	P
age[a]	34.14±7.79	35.53±9.72	0.467	34.81±8.01	35.84±9.72	0.645
sex[b]			0.237			0.237
male	9(0.25)	22(0.37)		11(0.34)	9(0.28)	
famale	27(0.75)	38(0.63)		21(0.66)	23(0.72)	
BMI[c]	24.03±3.34	24.42±4.32	0.797	24.29±3.27	25.55±4.02	0.096
HT[b]	7(0.19)	20(0.33)	0.143	8(0.25)	7(0.22)	0.768
tumor size(mm)[c]	7.39±2.65	11.28±7.63	**0.005**	7.69±2.66	7.31±3.36	0.375

Statistical significance P < 0.05 values are in bold.

[a] independent samples t-test was used.

[b] χ^2 test was used.

[c] Mann–Whitney U test was used.

3.2. Perioperative Indicators

After PSM, the operative time in the UAUB group was significantly longer than that in the OT group (132.60 ± 24.57 min vs. 66.38 ± 19.56 min, $P < 0.001$), while intraoperative blood loss was significantly lower (9.83 ± 9.24 ml vs. 15.41 ± 6.98 ml, $P < 0.001$). No significant differences were observed between the groups regarding the number of dissected lymph nodes ($P = 0.335$), number of metastatic lymph nodes ($P = 0.271$), duration of postoperative drainage ($P = 0.293$), total drainage volume ($P = 0.498$), length of hospital stay ($P = 0.215$), or 24-hour postoperative pain scores (VAS) ($P = 0.969$). Notably, the rate of parathyroid autotransplantation was significantly higher in the UAUB group compared to the OT group (33.3% vs. 15.6%, $P = 0.035$), suggesting that the indirect and novel approach of the UAUB technique may increase the difficulty of initial parathyroid identification and preservation, resulting in a higher autotransplantation rate (Table 3).

Table. 3. Comparison of the perioperative indicators.

Variables	UAUB (n=30)	OT (n=90)	P	UAUB(n=32)	BABA(n=32)	P
operative time(min)[a]	132.60±24.57	66.38±19.56	**<0.001**	130.41±23.37	138.59±27.22	0.266
tunnel hemorrhage[b]	2(0.07)	NA	NA	3	3	1.000
Blood loss(ml)[c]	9.83±9.24	15.41±6.98	**<0.001**	10.00±9.16	14.81±12.34	**0.023**
number of dissected LN [c]	7.43±4.53	8.54±4.97	0.335	7.56±3.84	9.22±3.98	0.095
number of metastatic LN [c]	0.67±1.32	1.10±1.70	0.271	0.53±1.13	1.11±1.76	0.109
rate of parathyroid autotransplantation [c]	10 (0.33)	14 (0.16)	**0.035**	10 (0.31)	4 (0.13)	0.129
drainage duration(days) [c]	2.47±0.73	2.34±0.66	0.293	2.50±0.72	2.41±0.67	0.525
total drainage amount(ml) [c]	81.33±39.72	87.33±32.75	0.498	88.91±37.09	123.91±47.38	**0.001**
Postoperative hospital days [c]	2.40±0.56	2.29±0.57	0.215	2.44±0.56	2.31±0.54	0.315
24-h VAS [c]	1.43±0.63	1.49±0.77	0.969	1.41±0.62	1.63±0.79	0.300

Statistical significance P < 0.05 values are in bold.

NA, not applicable.

[a] independent samples t-test was used.

[b] Fisher's exact test was used.

[c] Mann–Whitney U test was used.

No conversions to open surgery occurred in either the UAUB or BABA groups. Operative times were comparable between the two groups (130.41 ± 23.37 min vs. 138.59 ± 27.22 min, $P = 0.266$). However, the UAUB group demonstrated significantly less intraoperative blood loss (10.00 ± 9.16 ml vs. 14.81 ± 12.34 ml, $P = 0.023$) and a significantly lower total postoperative drainage volume (88.91 ± 37.09 ml vs. 123.91 ± 47.38 ml, $P = 0.001$). Other perioperative outcomes, including the number of lymph nodes dissected, length of hospital stay, and postoperative pain scores showed no significant differences between groups (all $P > 0.05$) (Table 3).

Although the difference in operative time between the two robotic approaches was not statistically significant, it is important to consider the impact of the learning curve [18]. The BABA procedure has been routinely performed at our center for many years, with surgeons exhibiting high proficiency. In contrast, the UAUB approach is relatively new, and its surgical technique is still in the early stages of adoption. To further assess the reproducibility and technical maturation of the UAUB approach, we performed a cumulative sum (CUSUM) analysis of operative time [19]. The learning curve demonstrated an inflection point at the 21st case, indicating a transition from the initial learning phase to a more stable and proficient stage of the procedure (Figure 2). This is superior to previous studies indicating that the learning curve for the BABA typically spans 30 to 50 cases [18].

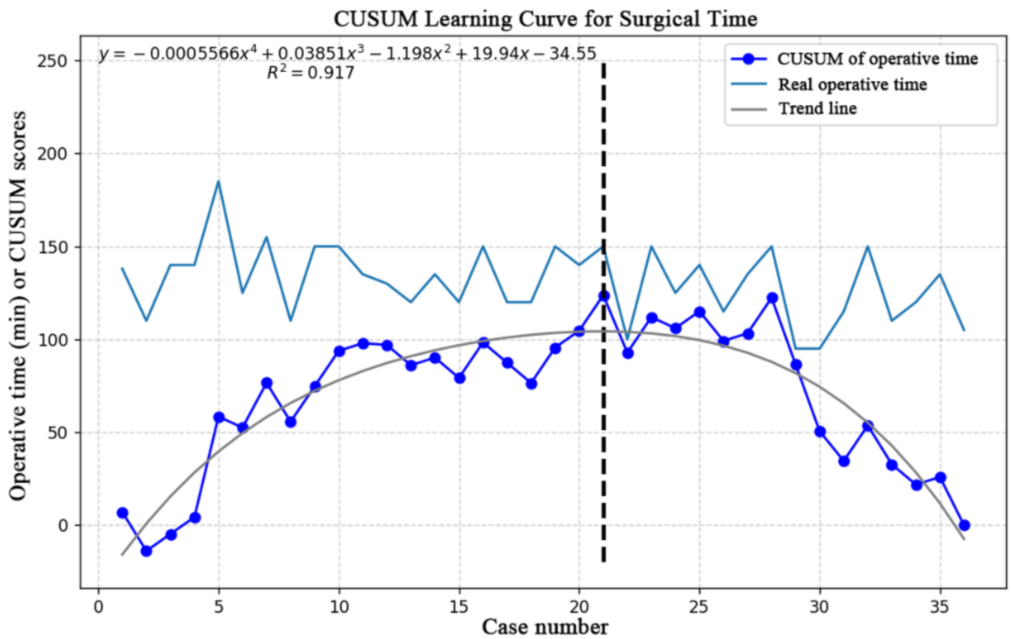

Fig. 2. Learning curve of operative time.

3.3. Complications

In the UAUB and OT groups, there was one case of transient RLN palsy and one case of transient hypoparathyroidism observed. No instances of permanent RLN injury, permanent hypoparathyroidism, infection, hematoma, or lymphatic fistula occurred in either group. The differences in complication rates between the groups were not statistically significant (P > 0.05). Between the UAUB and BABA groups, no cases of RLN injury or hypoparathyroidism were reported in either cohort. Two cases of minor postoperative cervical hematoma were noted exclusively in the BABA group; however, this difference was not statistically significant (*P* = 0.492).

Table. 4. Comparison of the complications.

Complications (n)	UAUB (n=30)	OT (n=90)	P	UAUB(n=32)	BABA(n=32)	P
Transient RLN palsy	1	1	0.439	0	0	NA
Permanent RLN palsy	0	0	NA	0	0	NA
Transient hypoparathyroidism	1	3	1.00	1	2	1.000
Permanent hypoparathyroidism	0	0	NA	0	0	NA
Infection	0	0	NA	0	0	NA
Hematoma	0	0	NA	0	2	0.492
lymphatic leakage	0	0	NA	0	0	NA

Statistical significance P < 0.05 values are in bold.
NA, not applicable.
All tabular data were analyzed with Fisher's exact test.

3.4. Subjective Evaluation of Patients

Compared to the OT group, patients in the UAUB group reported significantly higher cosmetic satisfaction (2.53 ± 0.51 vs. 2.21 ± 0.51, *P* = 0.004), lower scar-related self-consciousness (0.73 ± 0.17 vs. 1.19 ± 0.63, *P* = 0.002), and improved quality of life scores (1.13 ± 0.17 vs. 1.24 ± 0.21, *P* = 0.013).

In comparisons between robotic approaches, the UAUB group also demonstrated superior cosmetic satisfaction and reduced scar-related self-consciousness relative to the BABA group ($P = 0.042$ and $P = 0.026$, respectively). However, no significant difference in quality-of-life scores was found between these groups ($P = 0.667$).

These results suggest that the UAUB approach enhances postoperative aesthetic outcomes and patient satisfaction while maintaining comparable surgical safety and effectiveness.

Table. 5. Comparison of patients' subject evaluation.

Variables	UAUB (n=30)	OT (n=90)	P	UAUB(n=32)	BABA(n=32)	P
cosmetic satisfaction	2.53±0.51	2.21±0.51	**0.004**	2.47±0.51	2.19±0.54	**0.042**
scar-related self-consciousness	0.73±0.74	1.19±0.63	**0.002**	0.69±0.74	1.03±0.54	**0.026**
Quality of life	1.13±0.17	1.24±0.21	**0.013**	1.13±0.17	1.13±0.15	0.667

Statistical significance P < 0.05 values are in bold.
All tabular data were analyzed with the Mann–Whitney U test.

4. Discussion

In recent years, the incidence of PTC has steadily increased, with a growing proportion of cases occurring in young female patients who prioritize postoperative aesthetics, comfort, and quality of life. In this context, robotic thyroidectomy has become a significant advancement in minimally invasive thyroid surgery due to its high-definition visualization, multi-dimensional instrument dexterity, and the advantage of concealed incisions [4]. Commonly utilized robotic approaches include the bilateral BABA, TORT, TAA, and unilateral axillo-breast approach (UABAA). Each of these techniques differs in surgical cavity creation, extent of operative field exposure, and patient-reported outcomes.

In this study, we introduced an additional auxiliary port to optimize surgical field exposure and improve intracavitary stability during robotic thyroidectomy for the first time internationally. Utilizing PSM, we conducted a comparative analysis of perioperative outcomes and patient experiences between the unilateral axillo-unilateral breast (UAUB) technique, conventional OT, and the bilateral BABA robotic method. Our objective was to assess the safety, feasibility, and clinical value of the UAUB approach.

Our findings demonstrate that robotic thyroidectomy using the UAUB approach, enhanced by the addition of an auxiliary port, significantly improves exposure of inferior and deep anatomical structures, increases operative cavity stability, and minimizes the extent of tissue dissection. These technical refinements contribute to faster postoperative recovery and reduced patient discomfort. Specifically, during central compartment lymph node dissection, the UAUB technique provides superior visualization of low-lying structures while maintaining surgical flexibility and clear operative views, thereby enhancing overall surgical efficiency. This approach is especially well-suited for patients with unilateral lesions, particularly younger individuals with elevated cosmetic concerns.

The UAUB approach demonstrated strong surgical safety across key perioperative indicators. No intraoperative conversions were necessary, and both intraoperative blood loss and postoperative drainage volumes were significantly lower compared to the BABA group, reflecting reduced tissue trauma and decreased postoperative exudation. The coordinated use of auxiliary robotic arms and instruments facilitated precise anatomical identification, effective preservation of critical structures, and thorough lymph node dissection, especially in the lower central neck region. Furthermore, when compared to trans-subclavian laparoscopic surgery performed at our center, the UAUB approach achieved a significantly higher lymph node yield (8.70 ± 3.79 vs. 5.67 ± 3.29, $P < 0.001$), despite similar operative cavity boundaries, underscoring its enhanced efficacy in lymphadenectomy.

Although the UAUB approach is relatively new at our center, CUSUM analysis of operative times revealed a rapid learning curve, with cumulative deviations showing stabilization of procedure duration after approximately 21 consecutive cases. This indicates strong reproducibility and supports the potential for wider clinical adoption.

Regarding parathyroid preservation, robotic surgery presents some limitations compared to open surgery, primarily due to restricted exposure angles and the design of the operative cavity. Nevertheless, our findings showed no significant differences in the rates of parathyroid autotransplantation or transient hypoparathyroidism between the UAUB and BABA groups. This suggests that, within the shared robotic platform, effective parathyroid preservation is achievable through meticulous dissection, thorough vascular evaluation, and judicious use of autotransplantation techniques.

From the patient perspective, the UAUB approach delivered markedly superior outcomes in cosmetic satisfaction, scar-related concerns, and overall quality of life compared to both OT and the BABA robotic procedure. Patients particularly appreciated the lack of visible neck scars and the effective concealment of incisions within natural skin folds of the axilla and areolar regions. This strategic incision placement not only preserves surgical efficacy but also enhances aesthetic results, significantly reducing postoperative psychological stress, an important consideration especially for younger patients with heightened cosmetic expectations.

Nevertheless, this study has several limitations. Being a single-center retrospective analysis with a relatively small sample size, there is an inherent risk of selection bias. Additionally, postoperative satisfaction and quality of life measures relied on subjective patient self-reports, which can be influenced by individual expectations and external factors.

Moreover, since the UAUB approach is newly implemented at our center, the follow-up period was limited to a minimum of six months, restricting the ability to fully assess long-term oncologic outcomes, scar maturation, and the durability of quality-of-life benefits. To date, all patients have been followed for 6 to 18 months, and no structural recurrence has been observed. We explicitly acknowledge that longer-term follow-up with larger cohorts is still warranted to validate the sustained oncologic safety and functional benefits of the UAUB approach.

In conclusion, the UAUB robotic thyroidectomy technique effectively improves postoperative cosmetic outcomes and patient comfort without compromising oncologic safety or surgical efficacy. This approach offers a valuable combination of radical cancer treatment and aesthetic advantage, making it especially suitable for young female patients and those with heightened concerns about neck appearance. With further validation through multicenter prospective studies and longer-term follow-up, the UAUB technique holds significant promise for wider clinical adoption.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Due to patient privacy and institutional regulations, the raw data cannot be shared publicly.

Conflicts of Interest

None.

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Ethical Approval

The study protocol was approved by the Institutional Ethics Committee of The First Affiliated Hospital of Nanjing Medical University(Approval No. 2025-SR-495).

Consent

Written informed consent was obtained from all patients prior to inclusion in the study, in accordance with institutional guidelines and the Declaration of Helsinki.

Author Contributions

Chengyuan Li: Conception and design of the study, statistical analysis, data interpretation, manuscript drafting. Jingsheng Cai: Data collection, study design, critical revision of the manuscript, and supervision of the project. Jianing Zhou: Data collection, and preparation of figures and tables. Lijun Zhang: Data collection, and preparation of figures and tables. Xiang Zhang: Assistance in surgical procedures, clinical data acquisition, and follow-up. Houchao Tong: Assistance in surgical procedures, clinical data acquisition, and follow-up. Jianfei Wen: Support in perioperative management, data collection, and quality control. Heda Zhang: Contribution to study resources, visualization, and statistics verification. Meiping Shen: supervision, surgical performance, and corresponding author responsibilities. Yan Si: supervision, surgical performance, and corresponding author responsibilities.

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