Article

Comparative Analysis of Clinical Manifestations of Gasless Endoscopic Surgery via Transaxillary and Subclavicular Approaches in Unilateral cN0 Thyroid Cancer

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AIM: To compare the clinical efficacy and safety of gasless endoscopic radical thyroidectomy via the transaxillary approach versus the subclavicular approach for unilateral cN0 thyroid cancer.

METHODS: A total of 415 patients with unilateral cN0 thyroid cancer admitted between January 2022 and May 2025 were retrospectively included. After propensity score matching (PSM), patients were divided into Group A (gasless endoscopic radical thyroidectomy via the transaxillary approach, $n = 57$) and Group B (gasless endoscopic radical thyroidectomy via the subclavicular approach, $n = 57$). The clinical outcomes of these two approaches were compared.

RESULTS: Group B had significantly shorter operative time, lower postoperative drainage volume, and a higher rate of complete central compartment exposure than Group A ($p < 0.05$). Repeated-measures analysis of variance (ANOVA) showed significant main effects of time, group, and time-by-group interaction for interleukin-6 (IL-6), tumor necrosis factor alpha (TNF-α), incision pain scores, parathyroid hormone (PTH), and Quality of Life Questionnaire-Core 30 (QLQ-C30) scores ($p < 0.05$). Group B had a lower total complication rate and higher aesthetic satisfaction scores at 1 and 3 months postoperatively than Group A ($p < 0.001$).

CONCLUSIONS: Gasless endoscopic radical thyroidectomy via the subclavicular approach demonstrated potential short-term advantages over the transaxillary approach, including shorter operative time, improved central compartment exposure, attenuated inflammatory response, milder early postoperative pain, and more favorable trends in PTH levels and early quality-of-life recovery. However, given the limited 3-month follow-up period, the absence of significant differences in clinical hypocalcemia rates, and the lack of long-term oncological outcomes, these findings should be interpreted with caution.

Keywords: subclavicular approach; transaxillary approach; gasless endoscopic thyroidectomy; endoscopic thyroidectomy; quality of life

Introduction

Thyroid cancer, a malignant tumor arising from thyroid follicular epithelial cells, typically well differentiated and associated with a favorable prognosis. Early radical surgery remains the primary treatment [1]. Traditional open radical thyroidectomy is performed through an anterior cervical approach using an arched neck incision to expose the surgical field. This technique requires a relatively large incision and may injure the sensory and motor nerves of the anterior neck. Postoperatively, patients are prone to neck discomfort or a foreign body sensation, and the procedure leaves a prominent scar on the neck, compromising aesthetic outcomes [2]. Therefore, selecting a more optimal surgical approach is a current research focus. To minimize surgical invasiveness and improve aesthetic outcomes, various endoscopic thyroidectomy techniques have been developed, with the gasless approach gaining popularity due to its avoidance of carbon dioxide (CO_2)-related complications. Both the transaxillary and subclavicular approaches are widely used, each with distinct advantages and limitations [3]. The transaxillary approach offers excellent cosmetic results and minimal impact on swallowing function, but it involves extensive subcutaneous dissection and is technically challenging due to clavicle obstruction, making complete exposure of the central compartment more difficult [4]. In contrast, the subclavicular approach is technically less demanding and facilitates more direct access to the central compartment [5]. However, direct comparative evidence regarding oncological completeness and postoperative recovery of these two techniques is limited, and controversies remain regarding central compartment exposure methods and postoperative recovery. Therefore, in this study, we compared perioperative safety, central compartment exposure, postoperative recovery, parathyroid function, inflammatory response, short-term quality of life, and aesthetic satisfaction between the transaxillary and subclavicular approaches in patients with unilateral cN0 thyroid cancer after propensity score matching, with the primary

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goal to provide practical references for guiding individualized surgical approach selection.

Methods

Study Design, Patient Selection, and Statistical Analysis

Study Design and Data Source

This was a single-center, retrospective cohort study. Patients with unilateral cN0 thyroid cancer who underwent gasless endoscopic radical thyroidectomy between January 2022 and May 2025 were retrospectively screened. A total of 415 patients were initially included, including 257 patients treated via the transaxillary approach and 158 patients treated via the subclavicular approach. Baseline variables collected for matching and comparison included sex, age, body mass index (BMI), maximum tumor diameter, tumor location, concomitant Hashimoto's thyroiditis, and multifocality. Informed consent was obtained from all patients and their families preoperatively. This study was approved by the Ethics Committee of The First Affiliated Hospital of Chengdu Medical College (approval number: 2026CYFYIRB-BA-002).

Eligibility Criteria

Inclusion criteria: ① Preoperative fine-needle aspiration cytology suggests unilateral thyroid papillary carcinoma [6], which is confirmed by postoperative pathological examination, with the tumor located >5 mm from the thyroid isthmus. ② Patients met the following surgical indications: (a) neck ultrasound shows clinically node-negative (cN0) disease; (b) maximum tumor diameter ≤1 cm, with no extracapsular invasion (this criterion reflects the study's focus on minimally invasive endoscopic surgery for early-stage, localized thyroid cancer, in which gasless endoscopic approaches can achieve complete resection while minimizing trauma); (c) no prior treatment for thyroid cancer (first episode). ③ Patients underwent gasless endoscopic radical thyroidectomy via either the transaxillary or subclavicular approach, combined with ipsilateral central compartment lymph node dissection. ④ Age 18–70 years, with complete clinical and follow-up data.

Exclusion criteria: ① Preoperative assessment or intraoperative frozen-section pathological examination indicates definite cervical lymph node metastasis, or pathological diagnosis of medullary thyroid carcinoma, anaplastic carcinoma, or other non-differentiated thyroid malignancies. ② Patients who had previously undergone thyroid surgery, those with concurrent malignancies of other systems, or individuals with a history of radiotherapy or chemotherapy to the neck. ③ Severe underlying diseases of the heart, lungs, liver, or kidneys. ④ Tumor located at the entry point of the recurrent laryngeal nerve into the larynx. ⑤ Concomitant severe hyperthyroidism with grade III goiter or retrosternal goiter.

Propensity Score Matching

To reduce selection bias inherent in the retrospective design, propensity score matching (PSM) was performed before outcome comparison. A logistic regression model was constructed with surgical approach as the dependent variable and seven baseline variables (sex, age, BMI, maximum tumor diameter, tumor location, concomitant Hashimoto's thyroiditis, and multifocality) as covariates. Patients were matched at a 1:1 ratio using nearest-neighbor matching without replacement, with a caliper width of 0.2 standard deviations of the logit of the propensity score. After matching, 57 patients were retained in each group. Covariate balance was evaluated using standardized mean difference (SMD). An SMD <0.10 indicated optimal balance, whereas an SMD <0.20 was considered acceptable.

Post-hoc Power Analysis

This study was a retrospective observational study in which 415 patients were initially included. The adequacy of the final matched sample was evaluated using post-hoc power analysis. Based on the primary outcome measure—serum interleukin (IL)-6 levels at 24 h postoperatively—α was set to 0.05 (two-sided) and the power ($1-\beta$) to 0.90. Preliminary analysis showed that Cohen's d for the between-group difference in interleukin-6 (IL-6) at 24 h postoperatively was approximately 0.80. The calculation indicated that at least 34 patients were required per group. After 1:1 PSM, 57 patients per group were included, providing a statistical power greater than 95% and meeting the requirements for subsequent analysis.

Surgical Methods

Detailed descriptions regarding the surgical methods applied to these two groups are presented in the following:

Group A. Patients in Group A underwent gasless endoscopic radical thyroidectomy via the transaxillary approach. Under general anesthesia, patients were placed in the supine position with their neck extended and their head rotated to the contralateral side. The affected arm was abducted to 90°. After routine skin disinfection and sterile draping, a 4-cm incision was made along the axillary crease. The flap was dissected to the pectoralis major muscle, and the plane between the sternal and clavicular heads of the sternocleidomastoid muscle was separated to establish surgical access. Specialized retractors were used to facilitate creation of the working space. The omohyoid muscle was divided, and the anterior cervical strap muscles were retracted to expose the thyroid gland. The middle thyroid vein was identified and managed first. The thyroid lobe was then medially rotated, and the recurrent laryngeal nerve was dissected from a lateral approach. The parathyroid glands were identified, and dissection was performed close to the intrinsic thyroid capsule. Only small vascular branches directly entering the thyroid gland were ligated to preserve the main parathyroid blood supply, thereby maintaining the anatomical position and vascular integrity of the parathyroid gland as much as possible. If a parathyroid gland was inadvertently removed or devascularized, it was immediately minced and autotransplanted into the pectoralis major muscle. Central compartment lymph node dissection was then performed, followed by resection of the thyroid lobe and isthmus. After hemostasis was achieved, the surgical cavity was irrigated, a drainage tube was placed, and the incision was closed.

Group B. Patients in Group B underwent gasless endoscopic radical thyroidectomy via the subclavicular approach. Anesthesia and patient positioning were identical to those in Group A, with the ipsilateral shoulder slightly elevated. A 4-cm oblique primary incision was made inferior to the clavicle, and a 0.5-cm auxiliary incision was created for placement of the ultrasonic scalpel on the surgeon's right-hand side. The surgeon and the camera-holding assistant stood on the affected side. Dissection was performed beneath the platysma through the infraclavicular incision, and a special retractor was used to free the subcutaneous tissue up to the neck, mechanically retracting the operative field and suspending the skin before inserting the endoscope. The omohyoid muscle was freed, the sternothyroid muscle separated, and the sternal head of the sternocleidomastoid and strap muscles were retracted superiorly to expose the thyroid gland. Along the course of the inferior thyroid artery, careful dissection was carried out from inferior to superior within the tracheoesophageal groove to identify the recurrent laryngeal nerve. After confirming the relevant anatomical relationships, the vessels were cautiously ligated. Parathyroid glands were identified and preserved as described for Group A, with auto-transplantation if needed. The thyroid lobe and isthmus were resected. After achieving hemostasis, the surgical cavity was irrigated, a drainage tube was placed, and the incision was closed layer by layer.

Observation Indicators

A comparative analysis was performed between the two groups regarding perioperative indicators (operative time, intraoperative blood loss, number of lymph nodes dissected, postoperative drainage volume, postoperative hospital stay, parathyroid auto-transplantation, complete central compartment exposure), IL-6, tumor necrosis factor alpha (TNF-α), incision pain scores, parathyroid hormone (PTH) levels, cancer patient Quality of Life Questionnaire-Core 30 (QLQ-C30) scores, and complication rates (hoarseness, postoperative chyle leak, subcutaneous effusion, incisional infection, hypocalcemia, limb numbness, etc.), and aesthetic satisfaction scores. Preoperative ultrasound was used to measure maximum tumor diameter and location. Complete central compartment exposure was defined as the ability to adequately visualize, under endoscopic guidance, the recurrent laryngeal nerve, the tracheoesophageal groove, the prevertebral fascial area, and the contralateral thyroid isthmus stump, as well as the ability to complete central compartment lymph node dissection without the need for additional skin incisions or instrument ports.

Detection Methods

Peripheral venous blood (2 mL) was collected from patients of the two groups preoperatively and at 24 h and 72 h postoperatively. After standing at room temperature for half an hour, the blood specimens were centrifuged at 3500 r/min for 10 min with a radius of 12.5 cm. Serum levels of IL-6 and TNF-α were measured using a microplate reader (Shenzhen Mindray Bio-Medical Electronics Co., Ltd., model MR-96A, Yuexie Zhuzhun 20192220393) and enzyme-linked immunosorbent assay (ELISA) kits (Cat. No. JM-1007; Cat. No. JM-1046H) purchased from Shenzhen Jingmei Biological Engineering Co., Ltd. Peripheral venous blood (2 mL) was also collected from the patients preoperatively and at 1 day, 7 days, 1 month, and 3 months postoperatively, and was centrifuged under the same settings. Serum PTH levels were measured preoperatively, 1 day, 7 days, 1 month, and 3 months postoperatively using an automated chemiluminescence immunoassay system (Roche Diagnostics, model Cobas 6000 e601, Guoxie Zhujin 20172225170).

Incision Pain Assessment

The visual analog scale (VAS) was used to assess incisional pain at 2 h, 6 h, 12 h, 24 h, 48 h, 1 month, and 3 months postoperatively. The scale ranges from 0 to 10, with 0 indicating no discomfort and 10 denoting severe, intolerable pain [7].

QLQ-C30 Score

In this study, the functional scales of the EORTC QLQ-C30 were selected to assess patients' quality of life preoperatively and at 1 and 3 months postoperatively. This scale includes five dimensions: physical, cognitive, social, emotional, and role functioning. Each dimension is quantified on a 100-point scale, with higher scores indicating better functioning in the corresponding dimension [8].

Aesthetic Satisfaction

The VAS was also used to assess patients' aesthetic satisfaction with the appearance of the incision at 1 and 3 months postoperatively. The scale ranges from 0 to 10 points, with 0 indicating "extremely dissatisfied" and 10 denoting "very satisfied". Higher scores indicated greater aesthetic satisfaction with the postoperative incision appearance.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp, Armonk, NY, USA) was used for statistical analysis. The normality of continuous data was tested using the Kolmogorov–Smirnov test combined with Q-Q plots. Data conforming to a normal distribution are expressed as mean ± standard deviation (SD). Single time-point comparisons between the two groups for baseline data and perioperative indicators were performed using an independent samples t-test; within-group pre- and post-treatment comparisons at single time points were performed using the paired-samples t-test. Repeated-measures data were analyzed using two-way repeated-measures analysis of variance (ANOVA), with time as the within-group factor and surgical method as the between-group factor. The main effects of time and group, as well as the time × group interaction effect, were examined. When a significant interaction effect was detected, simple-effects analysis was performed, followed by post-hoc pairwise comparisons using the Bonferroni correction. For PSM, propensity scores were estimated using a logistic regression model including sex, age, BMI, maximum tumor diameter, tumor location, concomitant Hashimoto's thyroiditis, and multifocality. A 1:1 nearest-neighbor matching strategy without replacement was applied using a caliper width of 0.2 standard deviations of the logit of the propensity score. Matching quality was evaluated using SMD values before and after matching: an SMD <0.10 was considered optimal, whereas an SMD <0.20 was considered acceptable. Categorical variables are expressed as n (%) and were compared using the chi-square test; Fisher's exact probability test was used when expected frequencies were less than 5. A $p < 0.05$ was considered statistically significant.

Results

Comparison of Baseline Data Between Groups

Before matching, significant differences existed between Group A and Group B in age and BMI ($p < 0.05$). After matching, no significant differences were found in sex, age, BMI, maximum tumor diameter, tumor location, concomitant Hashimoto's thyroiditis, or multifocality ($p > 0.05$). The SMDs before matching ranged from 0.027 to 0.222, indicating considerable imbalance in certain covariates; after matching, all SMDs were reduced to below 0.20, confirming a substantial improvement in covariate balance. These results are presented in Tables 1,2.

Comparison of Perioperative Indicators

Group B had significantly shorter operative time, lower postoperative drainage volume, and a higher rate of complete central compartment exposure compared to Group A ($p < 0.05$). No significant differences were found between the two groups regarding intraoperative blood loss, number of lymph nodes dissected, postoperative hospital stay, or incidence of parathyroid auto-transplantation ($p > 0.05$) (see Table 3).

Comparison of Inflammatory Factors

The repeated-measures ANOVA showed significant main effects of time, group, and time-by-group interaction for IL-6 and TNF-α ($p < 0.001$). The intragroup comparisons showed that IL-6 and TNF-α levels at 24 h and 72 h postoperatively were significantly higher than preoperative levels in both groups ($p < 0.05$). The between-group comparative analyses revealed that Group B had lower IL-6 and TNF-α levels at 24 h and 72 h postoperatively compared to Group A ($p < 0.05$). The time-by-group interaction indicated significantly different change trends (see Table 4).

Comparison of Postoperative Incision Pain Scores

The repeated-measures ANOVA showed significant main effects of time, group, and time-by-group interaction for incision pain scores ($p < 0.001$). Pain scores in both groups increased during the early postoperative period, peaked at 6 h, and then gradually decreased over time. The between-group comparisons showed that Group B had significantly lower incision pain scores than Group A at 12 h, 24 h, 48 h, 1 month, and 3 months postoperatively ($p < 0.05$), whereas no significant between-group difference was observed at 2 h or 6 h postoperatively. The significant time-by-group interaction indicated different postoperative pain trajectories between the two approaches (see Table 5).

Comparison of Parathyroid Hormone Levels

The repeated-measures ANOVA demonstrated significant main effects of time, group, and time-by-group interaction for PTH ($p < 0.05$). The intragroup comparisons showed that PTH levels at 1 day and 7 days postoperatively were significantly lower compared to preoperative levels in both groups ($p < 0.05$), while no significant difference was found at 1 and 3 months postoperatively compared to preoperative levels ($p > 0.05$). According to the between-group comparative analyses, Group B had higher PTH levels at 1 day and 7 days postoperatively compared to Group A ($p < 0.05$), while no significant difference was found at 1 and 3 months postoperatively. The time-by-group interaction indicated significantly different change trends (see Table 6).

Comparison of QLQ-C30 Scores

The repeated-measures ANOVA demonstrated significant main effects of time, group, and time-by-group interaction for QLQ-C30 scores ($p \leq 0.001$). Based on the intragroup comparisons, both groups of patients experienced significant improvements in physical, cognitive, social, emotional, and role function scores at 1 and 3 months postoperatively compared with their respective preoperative levels ($p < 0.05$). Intergroup comparisons showed that Group B had higher scores in physical, cognitive, social, emotional, and role functions at 1 and 3 months compared to Group A ($p < 0.05$). The time-by-group interaction indicated significantly different change trends (see Table 7).

Comparison of Complications

There were no statistically significant differences between Group A and Group B in the incidence of hoarseness, postoperative chyle leak, subcutaneous effusion, incisional infection, hypocalcemia, or limb numbness ($p > 0.05$). The

Table 1. Comparison of baseline data before matching.

Baseline data	Group A (n = 257)	Group B (n = 158)	Statistics	p-value	SMD
Sex, n (%)			$\chi^2 = 0.402$	0.526	0.064
Male	41 (15.95)	29 (18.35)			
Female	216 (84.05)	129 (81.65)			
Age (years)	47.05 ± 6.39	45.58 ± 7.01	$t = 2.192$	0.029	0.222
BMI (kg/m^2)	23.42 ± 1.98	23.01 ± 2.06	$t = 2.017$	0.044	0.204
Maximum tumor diameter (cm)	0.61 ± 0.13	0.62 ± 0.16	$t = -0.696$	0.487	0.070
Tumor location, n (%)			$\chi^2 = 0.422$	0.516	0.066
Left	138 (53.70)	90 (56.96)			
Right	119 (46.30)	68 (43.04)			
Concomitant Hashimoto's Thyroiditis, n (%)			$\chi^2 = 1.139$	0.286	0.107
Yes	55 (21.40)	41 (25.95)			
No	202 (78.60)	117 (74.05)			
Multifocality, n (%)			$\chi^2 = 0.072$	0.789	0.027
Yes	35 (13.62)	23 (14.56)			
No	222 (86.38)	135 (85.44)			

Abbreviations: BMI, body mass index; SMD, standardized mean difference.

Table 2. Comparison of baseline data after matching and covariate balance.

Baseline data	Group A (n = 57)	Group B (n = 57)	Statistics	p-value	SMD
Sex, n (%)			$\chi^2 = 0.525$	0.469	0.136
Male	9 (15.79)	12 (21.05)			
Female	48 (84.21)	45 (78.95)			
Age (years)	48.52 ± 6.36	47.91 ± 6.77	$t = 0.496$	0.621	0.093
BMI (kg/m^2)	23.25 ± 2.10	23.18 ± 2.33	$t = 0.168$	0.867	0.032
Maximum tumor diameter (cm)	0.60 ± 0.14	0.61 ± 0.15	$t = -0.368$	0.714	0.069
Tumor location, n (%)			$\chi^2 = 0.140$	0.708	0.070
Left	27 (47.37)	29 (50.88)			
Right	30 (52.63)	28 (49.12)			
Concomitant Hashimoto's Thyroiditis, n (%)			$\chi^2 = 0.461$	0.497	0.127
Yes	14 (24.56)	11 (19.30)			
No	43 (75.44)	46 (80.70)			
Multifocality, n (%)			$\chi^2 = 0.077$	0.782	0.052
Yes	8 (14.04)	7 (12.28)			
No	49 (85.96)	50 (87.72)			

Table 3. Comparison of perioperative indicators between groups.

Group	n	Operative time (min)	Intraoperative blood loss (mL)	Number of lymph nodes dissected (n)	Postoperative drainage volume (mL)	Postoperative hospital stay (days)	Parathyroid auto-transplantation, n (%)	Complete central compartment exposure, n (%)
Group A	57	108.85 ± 15.74	14.85 ± 2.96	4.21 ± 0.85	110.14 ± 18.85	3.64 ± 0.41	30 (52.63)	50 (87.72)
Group B	57	89.63 ± 12.08	14.55 ± 3.12	4.26 ± 0.81	98.63 ± 16.41	3.71 ± 0.35	27 (47.37)	57 (100.00)
Statistics		$t = 7.313$	$t = 0.527$	$t = -0.322$	$t = 3.475$	$t = -0.981$	$\chi^2 = 0.316$	$\chi^2 = 7.458$
p-value		<0.001	0.599	0.748	0.001	0.329	0.574	0.006

Note: Data are expressed as mean ± SD.

total complication rate in Group B was significantly lower than that in Group A ($p < 0.05$) (see Table 8).

Comparison of Aesthetic Satisfaction Between the Two Groups

The satisfaction scores regarding the incision appearance at 1 and 3 months postoperatively in Group B were significantly higher than those in Group A ($p < 0.001$) (see Table 9).

Discussion

Thyroid cancer is one of the most common malignancies of the head and neck region, with an incidence approxi-

Table 4. Comparison of inflammatory factors between groups.

Group	n	IL-6 (ng/L)			TNF-α (ng/L)		
		Preoperative	Postoperative 24 h	Postoperative 72 h	Preoperative	Postoperative 24 h	Postoperative 72 h
Group A	57	6.85 ± 1.89	54.42 ± 7.85*	37.12 ± 6.54*	3.96 ± 0.45	47.86 ± 5.96*	26.14 ± 4.78*
Group B	57	6.77 ± 1.93	48.57 ± 6.61$^{*\#}$	26.02 ± 5.85$^{*\#}$	4.02 ± 0.51	41.04 ± 5.33$^{*\#}$	19.85 ± 4.32$^{*\#}$
F-value		F_{time} = 322.524, F_{group} = 24.748, $F_{time×group}$ = 32.865			F_{time} = 298.452, F_{group} = 20.363, $F_{time×group}$ = 28.743		
p-value		p_{time} <0.001, p_{group} <0.001, $p_{time×group}$ <0.001			p_{time} <0.001, p_{group} <0.001, $p_{time×group}$ <0.001		

Note: $^{*}p < 0.05$ vs. preoperative value within the same group; $^{\#}p < 0.05$ vs. Group A at the same time point. Data are expressed as mean ± SD.

Abbreviations: IL-6, interleukin-6; TNF-α, tumor necrosis factor alpha.

Table 5. Comparison of postoperative incision pain scores between groups.

Group	n	Postoperative 2 h	Postoperative 6 h	Postoperative 12 h	Postoperative 24 h	Postoperative 48 h	Postoperative 1 month	Postoperative 3 months
Group A	57	2.41 ± 0.52	3.86 ± 0.69	3.69 ± 0.74	3.24 ± 0.58	2.47 ± 0.42	1.89 ± 0.36	1.57 ± 0.23
Group B	57	2.38 ± 0.57	3.74 ± 0.52	3.03 ± 0.65$^{\#}$	2.81 ± 0.47$^{\#}$	2.01 ± 0.35$^{\#}$	1.51 ± 0.32$^{\#}$	1.25 ± 0.18$^{\#}$
F-value		F_{time} = 286.742, F_{group} = 17.523, $F_{time×group}$ = 14.396						
p-value		p_{time} <0.001, p_{group} <0.001, $p_{time×group}$ <0.001						

Note: $^{\#}p < 0.05$ vs. Group A at the same time point. Data are expressed as mean ± SD.

Table 6. Comparison of parathyroid hormone levels between groups.

Group	n	Preoperative	Postoperative 1 day	Postoperative 7 days	Postoperative 1 month	Postoperative 3 months
Group A	57	64.85 ± 12.05	47.85 ± 10.46*	56.85 ± 10.63*	62.98 ± 13.74	63.32 ± 14.15
Group B	57	66.08 ± 14.71	53.69 ± 11.87$^{*\#}$	61.11 ± 10.26$^{*\#}$	64.72 ± 12.97	63.71 ± 12.89
F-value		F_{time} = 147.896, F_{group} = 10.632, $F_{time×group}$ = 12.726				
p-value		p_{time} <0.001, p_{group} =0.002, $p_{time×group}$ <0.001				

Note: $^{*}p < 0.05$ vs. preoperative value within the same group; $^{\#}p < 0.05$ vs. Group A at the same time point. Data are expressed as mean ± SD (unit: pg/mL).

Table 7. Comparison of QLQ-C30 scores between groups.

Group	n	Physical function			Cognitive function		
		Preoperative	Postoperative 1 month	Postoperative 3 months	Preoperative	Postoperative 1 month	Postoperative 3 months
Group A	57	70.12 ± 3.95	78.89 ± 4.12*	80.02 ± 4.33*	71.54 ± 4.36	81.01 ± 4.56*	83.32 ± 4.07*
Group B	57	68.95 ± 4.12	83.94 ± 4.26$^{*\#}$	86.98 ± 4.51$^{*\#}$	70.89 ± 4.61	85.52 ± 4.47$^{*\#}$	86.98 ± 5.11$^{*\#}$
F-value		F_{time} = 195.857, F_{group} = 18.632, $F_{time×group}$ = 20.853			F_{time} = 195.620, F_{group} = 16.356, $F_{time×group}$ = 20.415		
p-value		p_{time} <0.001, p_{group} <0.001, $p_{time×group}$ <0.001			p_{time} <0.001, p_{group} <0.001, $p_{time×group}$ <0.001		
Group	n	Social function			Role function		
		Preoperative	Postoperative 1 month	Postoperative 3 months	Preoperative	Postoperative 1 month	Postoperative 3 months
Group A	57	75.85 ± 4.01	81.14 ± 4.26*	82.74 ± 4.06*	72.85 ± 4.36	77.87 ± 5.03*	80.12 ± 4.69*
Group B	57	76.22 ± 3.83	85.87 ± 4.23$^{*\#}$	87.36 ± 4.28$^{*\#}$	71.97 ± 4.47	83.65 ± 4.74$^{*\#}$	85.63 ± 5.07$^{*\#}$
F-value		F_{time} = 179.876, F_{group} = 14.753, $F_{time×group}$ = 18.326			F_{time} = 177.415, F_{group} = 13.254, $F_{time×group}$ = 21.543		
p-value		p_{time} <0.001, p_{group} <0.001, $p_{time×group}$ <0.001			p_{time} <0.001, p_{group} = 0.001, $p_{time×group}$ <0.001		
Group	n	Emotional function					
		Preoperative	Postoperative 1 month	Postoperative 3 months			
Group A	57	67.46 ± 5.32	75.85 ± 6.02*	81.11 ± 5.89*			
Group B	57	66.99 ± 5.06	82.21 ± 5.41$^{*\#}$	86.33 ± 5.94$^{*\#}$			
F-value		F_{time} = 178.859, F_{group} = 15.632, $F_{time×group}$ = 22.520					
p-value		p_{time} <0.001, p_{group} <0.001, $p_{time×group}$ <0.001					

Note: $^{*}p < 0.05$ vs. preoperative value within the same group; $^{\#}p < 0.05$ vs. Group A at the same time point. Data are expressed as mean ± SD.

Abbreviation: QLQ-C30, Quality of Life Questionnaire-Core 30.

mately three times higher in women than in men, predominantly affecting young and middle-aged adults, particularly those aged 20–50 years [9]. Its pathogenesis is complex, with existing evidence implicating multiple factors, includ-

Table 8. Comparison of complications between groups.

Group	n	Hoarseness	Postoperative chyle Leak	Subcutaneous effusion	Incisional infection	Hypocalcemia	Limb numbness	Total complications
Group A	57	3 (5.26)	1 (1.75)	4 (7.02)	1 (1.75)	3 (5.26)	4 (7.02)	16 (28.07)
Group B	57	1 (1.75)	0 (0.00)	2 (3.51)	0 (0.00)	1 (1.75)	3 (5.26)	7 (12.28)
Statistics		-	-	-	-	-	-	$\chi^2 = 4.412$
p-value		0.618*	1.000*	0.679*	1.000*	0.618*	1.000*	0.036

Note: *Fisher's exact test was used, as expected frequencies <5, and only the p-value is reported. Data are expressed as n (%). -, indicates that no test statistic was reported.

Table 9. Comparison of aesthetic satisfaction between the two groups.

Group	n	Postoperative 1 month	Postoperative 3 months
Group A	57	7.82 ± 1.05	8.14 ± 0.93
Group B	57	8.74 ± 0.92	9.05 ± 0.82
t-value		−4.975	−5.541
p-value		<0.001	<0.001

ing oncogenes, iodine intake, and ionizing radiation [10]. cN0 thyroid cancer represents an early stage of the disease characterized by the absence of lymph node or distant metastasis, where surgical treatment yields an excellent prognosis, with reported cure rates approaching 100% [11]. Traditional thyroidectomy via the midline cervical (linea alba) approach is associated with significant surgical trauma and visible cervical scarring, which may affect aesthetic outcomes. To overcome these limitations, alternative approaches, such as the transaxillary, transoral vestibular, breast/areolar, and retroauricular approaches, have gradually been introduced into clinical practice [12,13].

Both the transaxillary and subclavicular approaches are commonly used surgical techniques in clinical practice, and compared to the traditional midline cervical approach, neither affects aesthetic outcomes [14]. The transaxillary approach, with its incision located within the natural axillary crease, makes it suitable for unilateral early-stage, low-risk thyroid cancer patients. However, this procedure requires a longer working distance and is technically more demanding [15]. The subclavicular approach, with its incision located below the clavicle, allows the scar to be concealed by clothing such as a collar. This technique involves a shorter, more direct surgical pathway, facilitating precise manipulation [5]. In the present study, the subclavicular approach was associated with shorter operative time, less postoperative drainage, and a higher rate of complete central compartment exposure. These findings suggest that the subclavicular approach for radical thyroidectomy is more surgically efficient, results in less postoperative drainage, and is more conducive to achieving complete central compartment exposure. The transaxillary approach requires flap dissection starting from the lateral border of the pectoralis major muscle, resulting in greater surgical trauma and more postoperative drainage. Intraoperatively, identifying the sternocleidomastoid muscle plane is more technically challenging, and obstruction by the clavicle and sternoclavicular joint increases the technical complexity of performing thyroidectomy and lymph node dissection, thus prolonging the operative time. The subclavicular approach, less affected by the sternoclavicular joint, offers a smaller visual blind spot and a larger operative space. The infraclavicular incision, through retraction and suspension, provides better central compartment exposure, reducing the technical difficulty and shortening the operative time. This finding is consistent with Zheng et al. [5], who also reported that the subclavicular approach requires a shorter operative time. However, unlike the study by Lee et al. [15], which demonstrated reduced lymph node yield with the transaxillary approach, our study found no significant difference in this regard, possibly due to the use of high-definition endoscopic systems and standardized vessel control methods in both groups.

Based on a previous study, the number of lymph nodes dissected is correlated with central compartment exposure, with improved inferior visualization facilitating more complete dissection [16]. Complete central compartment exposure via the transaxillary approach is relatively difficult and may affect lymph node dissection [17]. However, this study suggested no significant difference in lymph node yield, intraoperative blood loss, or length of hospital stay. This is possibly attributed to the use of high-definition endoscopic systems in both approaches, which allows precise vessel identification, and similar use of ultrasonic/high-frequency electrocoagulation devices for vessel control. Both approaches focus on thyroid and central compartment lymph nodes without a neck incision, typically allowing drain removal within 24–48 hours and discharge within 3–5 days.

Surgical trauma triggers inflammation, activating pro-inflammatory factors like TNF-α and IL-6, contributing to pain and stress, which impede recovery [18,19,20]. Previous studies have often used indicators such as pain scores, postoperative recovery time, and complication rates to indirectly assess surgical trauma. This study attempted to objectively evaluate the degree of trauma using inflammatory markers. The present study found that the levels of IL-6 and TNF-α in both groups were elevated at 24 h and 72 h postoperatively compared with preoperative levels; patients undergoing the subclavicular approach had lower levels of IL-6 and TNF-α at 24 h and 72 h postoperatively than those undergoing the transaxillary approach. In addition, patients undergoing the subclavicular approach had lower incision pain scores at 12 h, 24 h, 48 h, 1 month, and 3 months postoperatively compared with those undergoing the transaxillary approach. These findings suggest that the gasless endoscopic radical thyroidectomy via the subclavicular approach induces a milder inflammatory stress response and is associated with less pain. During thyroid cancer resection, the subclavicular approach creates an incision located below the clavicle, providing direct vertical access to the thyroid region through the interval between the sternocleidomastoid muscle heads. With this approach, the surgical path is shorter and more linear, eliminating the need to establish a long subcutaneous operating channel. Additionally, this approach requires only limited dissection of the anterior cervical strap muscles without extensive flap elevation. In contrast, the transaxillary approach requires the creation of a subcutaneous tunnel extending from the axilla, traversing the anterior chest wall to the neck, involving a larger area of dissection that encompasses extensive subcutaneous tissue and fascial layers, thereby resulting in more extensive tissue trauma. Greater surgical trauma leads to increased release of inflammatory cytokines such as TNF-α and IL-6, which contributes to a more pronounced postoperative inflammatory response. However, no statistically significant differences were observed in incision pain scores between the two groups at 2 h and 6 h postoperatively. This may be attributed to the fact that differences in the extent of trauma only became evident after the complete resolution of the anesthetic effect. At 2 h and 6 h postoperatively, the effects of anesthesia in both groups had not completely resolved, with residual analgesic effects still covering the surgical area and temporarily masking pain perception.

During thyroid surgery, injury to the parathyroid glands can impair postoperative PTH secretion, leading to hypocalcemia and associated serious complications [21,22]. Therefore, parathyroid tissue with compromised blood supply should be auto-transplanted into the pectoralis major muscle during the procedure to help restore endocrine function and prevent permanent postoperative hypoparathyroidism [23,24]. This study found that PTH levels in both groups decreased at 1 day and 7 days postoperatively compared with preoperative levels; however, patients undergoing the subclavicular approach had higher PTH levels at 1 day and 7 days postoperatively than those undergoing the transaxillary approach, suggesting that the subclavicular approach is more favorable for preserving parathyroid function. The subclavicular approach creates an incision located below the clavicle, with direct access to the thyroid region through the sternocleidomastoid muscle interval. This approach offers a shorter surgical path that is closer to the thyroid gland's original position, avoids the creation of a long subcutaneous tunnel, requires only limited dissection of the anterior cervical strap muscles, and does not involve extensive flap elevation or traversal of multiple anatomical layers. These features reduce mechanical traction and compression on the parathyroid glands and their surrounding microvascular networks, thereby lowering the risk of parathyroid ischemia or inadvertent injury due to surgical manipulation. In contrast, the transaxillary approach requires a route from the axilla to the neck, traversing multiple anatomical layers, which increases the risk of parathyroid gland injury. However, no statistically significant difference was observed in the incidence of hypocalcemia between the two groups in this study, and this result is inconsistent with the findings on serum PTH levels. This discrepancy may be attributed to the relatively small sample size, which resulted in low statistical power and prevented the detection of actual differences between the groups. Further studies with larger sample sizes are needed to investigate whether differences exist between the two surgical approaches with respect to parathyroid gland injury.

The QLQ-C30 score is an internationally recognized assessment system for evaluating the quality of life of cancer patients. This study found that in both Groups A and B, the scores for physical, cognitive, social, emotional, and role functions at 1 month and 3 months postoperatively were higher than the preoperative scores. Patients who underwent gasless endoscopic radical thyroidectomy via the subclavicular approach had higher scores for physical, cognitive, social, and role functions, as well as higher aesthetic satisfaction scores, at 1 month and 3 months postoperatively compared with those who underwent the resection procedure via the transaxillary approach. This suggests that gasless endoscopic radical thyroidectomy via the subclavicular approach can better improve short-term postoperative quality of life and enhance patients' aesthetic satisfaction, primarily due to the minimal surgical trauma caused by the subclavicular approach. This study also found that there were no statistically significant differences in the incidence of hoarseness, postoperative lymphatic leakage, subcutaneous effusion, incisional infection, hypocalcemia, or numbness of the hands and feet. This is because both procedures are performed with endoscopic assistance, which facilitates clear identification of key structures, such as the recurrent laryngeal nerve and parathyroid glands. Combined with intraoperative neuromonitoring, both approaches can reduce the risk of postoperative complications, such as hoarseness and hypocalcemia.

Several limitations of this study should be acknowledged. First, this was a single-center retrospective study with a relatively small sample size (only 57 patients per group after PSM), and the results are potentially subject to selection bias. Additionally, the findings may have been influenced by surgeon experience and technical proficiency, potentially limiting their generalizability to other clinical settings. Second, the follow-up period utilized in this study was limited to 3 months. Given the short follow-up period, we were unable to evaluate long-term oncological outcomes, such as recurrence and survival rates. Lastly, although PSM was used to control for confounding factors, the retrospective study design cannot eliminate selection bias or residual confounding. Thus, future large-scale prospective studies are warranted to further validate these results.

Conclusions

In this propensity score-matched cohort of patients with unilateral cN0 thyroid cancer, gasless endoscopic radical thyroidectomy via the subclavicular approach was associated with shorter operative time, improved central compartment exposure, a less pronounced postoperative inflammatory response, less early postoperative pain, and more favorable early recovery of PTH levels and quality of life compared with the transaxillary approach, without an increased risk of postoperative complications. Nevertheless, these advantages did not translate into a statistically significant reduction in clinical hypocalcemia, and the 3-month follow-up period had precluded assessment of long-term oncological outcomes or sustained quality-of-life benefits. Additionally, with a relatively small sample size used in this study, our findings could be unknowingly biased. Despite these shortcomings, the subclavicular approach appears to be a promising alternative for the treatment of unilateral cN0 thyroid cancer, and its efficacy and safety should be further evaluated in large-scale, multicenter prospective studies with extended follow-up.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

XSL conceived and conducted the research, drafted and revised the manuscript; AKJ participated in study design and performed data analysis; QLH collected the data and provided professional clinical guidance for the research. All authors have been involved in revising the manuscript critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This research strictly adheres to all the principles of the Declaration of Helsinki. Informed consent was obtained from all patients and families preoperatively. This study was approved by the Ethics Committee of The First Affiliated Hospital of Chengdu Medical College (approval number: 2026CYFYIRB-BA-002).

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Conflict of Interest

The authors declare no conflict of interest.

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