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Original Article

Gasless endoscopic thyroidectomy for papillary thyroid microcarcinoma: safety and feasibility

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Abstract: Objective: To evaluate the comparative effectiveness of gasless endoscopic thyroidectomy (GET) versus conventional open thyroidectomy (COT) in the management of papillary thyroid microcarcinoma (PTMC). Methods: A retrospective study of 150 PTMC cases was conducted, comparing patients treated with COT (COT group, n=70) to those undergoing GET (GET group, n=80). Key outcomes, including operating time (OT), hospital length of stay (HLOS), intraoperative blood loss (IBL), postoperative drainage volume, central lymph node dissection count, efficacy, postoperative complications, pain intensity, thyroid hormone levels, inflammatory cytokines, and cosmetic satisfaction, were compared between the groups. Results: The GET group demonstrated significantly longer OT and greater postoperative drainage, therapeutic efficacy, and aesthetic satisfaction compared to the COT group(all $P<0.05$). However, the GET group showed lower IBL, pain intensity, and complication rates (all $P<0.05$). Additionally, variations in thyroid hormones and inflammatory cytokines were less pronounced in the GET group (all $P<0.05$). There were no significant differences in HLOS or the number of central neck lymph nodes dissected between the two groups (both $P<0.05$). Conclusion: GET surgery is a safe and feasible option for PTMC. It offers advantages such as better thyroid function preservation, reduced invasiveness and physiological stress, superior cosmetic outcomes, and less postoperative pain, supporting its clinical adoption.

Keywords: Papillary thyroid microcarcinoma, gasless endoscopic thyroidectomy, safety, clinical efficacy

Introduction

Thyroid cancer (TC) is a common endocrine malignancy, accounting for nearly one-third of all global malignancies [1, 2]. Most cases of TC arise from well-differentiated tumors of follicular cells, classified as papillary thyroid carcinoma (PTC), follicular thyroid carcinoma, and Hürthle cell carcinoma, with PTC comprising 79% of cases [3-5]. Papillary thyroid microcarcinoma (PTMC) refers to PTCs that are 1 cm or smaller [6]. The detection rate of PTMC has significantly increased due to advances in medical imaging technology. However, this type of tumor grows slowly and is often dormant, posing minimal risk to patients' lives [7, 8]. Some reports suggest that PTMC is over diagnosed, which may lead to unnecessary patient anxiety and negatively affect quality of life [9]. Therefore, the primary goal of clinical treatment for PTMC should focus on addressing patients' needs, particularly their aesthetic and pain concerns, and identifying safer, more satisfactory treatment options to improve clinical outcomes.

Surgical resection is the primary treatment for PTMC and has been shown to greatly improve prognosis [10]. In conventional open thyroidectomy (COT), the incision is made along the axillary midline, often resulting in scar adhesion and hypertrophy, which leaves permanent surgical scars on the neck, impacting patients' psychological well-being and quality of life [11, 12]. In contrast, endoscopic thyroidectomy eliminates the issue of visible scars by utilizing discreet incisions through the axillary approach, and the use of the endoscope system provides high-quality images to facilitate surgery [13]. However, Cho et al. [14] noted that CO_2 insufflation during transaxillary endoscopic thyroidectomy may cause complications, indicating a need to improve the safety of the procedure.

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Gasless endoscopic thyroidectomy (GET), which includes both transaxillary and subclavian approaches, has been shown to outperform COT in right-lobe thyroid cancer patients by alleviating postoperative pain, reducing neck disability (3-day assessment), and lowering swallowing impairment (1-month evaluation), leading to better outcomes [15]. Additionally, GET results in barely noticeable scars, meeting high aesthetic demands [16].

This study focuses on GET and aims to explore the differences in safety, postoperative pain, and cosmetic effects between GET and COT in the treatment of PTMC, providing a new reference for PTMC treatment.

Materials and methods

Case selection

This research included 150 PTMC patients who consecutively presented to Pingyang County People's Hospital for treatment between October 2018 and July 2021. Of these, 70 patients were managed with COT (COT group, n=70), and the remaining patients underwent GET (GET group, n=80). The study was approved by the Ethics Committee of Pingyang County People's Hospital.

Patients were eligible for inclusion if they had unilateral thyroid lesions ≤1 cm confirmed by color Doppler ultrasound and CT, were pathologically diagnosed with PTMC postoperatively, and had no cervical lymph node or distant metastasis, nor a history of neck surgery or radiotherapy. Exclusion criteria included patients under 18 years of age, those with thyroiditis, hyperthyroidism, uncontrolled underlying diseases, bilateral lesions, lymph node metastases, or tumors invading surrounding tissues.

Intervening methods

COT group: Patients were placed in the supine position after successful intubation and general anesthesia. A 5 cm curved incision was made about two fingers from the suprasternal notch, and the cervical linea alba was cut to expose the thyroid gland. The inferior and superior thyroid poles and surrounding blood vessels were coagulated and severed. The recurrent laryngeal nerve was routinely exposed, and the thyroid gland was removed. After intraoperative frozen pathological examination confirmed PTMC, central neck lymph node dissection was performed. The surgical cavity was irrigated, hemostasis ensured, a drainage tube was inserted, and the cavity was closed.

GET group: Anesthesia was the same as in the COT group. The surgical approach - either transaxillary or transclavicular - was selected based on the patient's condition and surgical indications.

Transaxillary approach: The patient was placed in a supine position with the shoulder and neck padded high and the upper arm abducted and fixed to expose the axilla. Then, a 4 cm oblique incision was made along the axillary skin fold. After dissecting the skin flap, a 5 cm incision was created at the distal end, and a trocar was inserted for the operating hole. A dedicated retractor was used, and the flap was dissected along the muscle fascia. The tunnel was extended to the cervical area, with careful attention to the jugular vein. The thyroid lobe was exposed, the superior parathyroid gland identified, and lymph node dissection performed. The surgical cavity was irrigated, hemostasis ensured, a drainage tube was inserted, and the cavity was closed.

Transclavicular approach: The patient was positioned supine with shoulders elevated and head slightly tilted backward. A nerve-monitoring endotracheal tube was inserted and secured. A 3-4 cm incision was marked along the skin fold under the clavicle, with the upper edge against the clavicle's inferior border. After securing the anesthesia screen on the contralateral side, the head was turned, and an incision was made in the natural skin crease. The platysma muscle was dissected, and the sternocleidomastoid muscle's clavicular and sternal heads were identified. Dissection was carried through the space between these muscle bellies to expose the thyroid gland and central compartment. The isthmus was severed, and specimens from the thyroid and central region were collected.

Post-removal, the patient's head was turned to the operative side, and dissection continued between the thyroid gland and trachea, with care taken to avoid injury. The recurrent laryngeal nerve was located and protected. Lateral dissection along the carotid sheath was per-

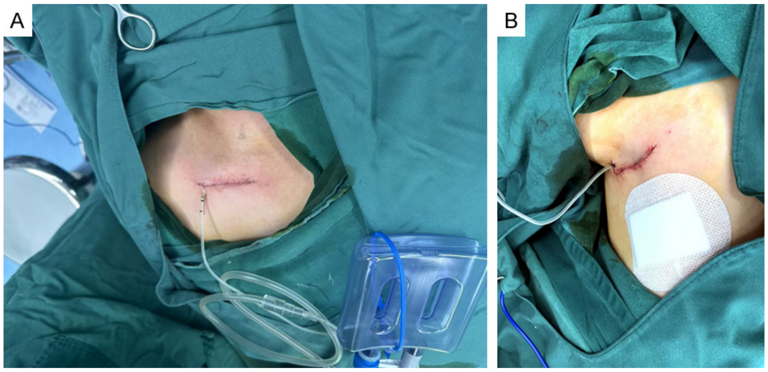

Figure 1. Gasless endoscopic thyroidectomy approaches. A. Non-pneumatic laparoscopic surgery via the axillary approach: an operating channel can be established by utilizing the natural anatomical gap. B. Transclavicular route: The infraclavicular incision optimizes exposure of the central lymph node compartment.

formed, with attention to the internal jugular vein. The thyroid gland's upper and lower poles were addressed, and the external branch of the superior laryngeal nerve, along with the parathyroid glands, were safeguarded. The thyroid gland was removed, the surgical area checked for bleeding, flushed with warm distilled water, and a drain was placed before closing the incision in layers.

See **Figure 1** for the two surgical approaches.

Data collection

We recorded data on surgical efficiency, clinical efficacy, postoperative adverse reactions (ARs), postoperative pain, and aesthetic satisfaction. Primary endpoints included surgical efficiency, clinical outcomes, efficacy, safety, postoperative pain, and aesthetic satisfaction. Secondary measures included thyroid hormone levels and inflammatory markers.

Surgical efficiency: Operation time (OT) and hospital length of stay (HLOS) were recorded.

Clinical outcomes: Intraoperative blood loss (IBL), postoperative drainage, and the number of central neck lymph nodes dissected were recorded.

Efficacy: Patients were classified as markedly effective (complete symptom resolution and normalized thyroid function), effective (symptom and thyroid function improvement), or ineffective. Total effective rate = (Markedly Effective + Effective Cases)/Total Cases × 100%.

Safety: Postoperative complications, including temporary recurrent laryngeal nerve paralysis (RLNP), postoperative hematoma (POH), postoperative infection (POI), and anterior cervical discomfort during swallowing, were observed.

Postoperative pain: The Visual Analogue Scale (VAS) was used to assess pain intensity on the 3rd postoperative day [17].

Thyroid hormones: Morning fasting venous blood (3 mL) was collected from patients both pre- and post-treatment. Serum was then isolated for radioimmunoassay to measure thyroid-stimulating hormone (TSH), free triiodothyronine (FT3), and free thyroxine (FT4) levels. The manufacturer's instructions for the kits were strictly adhered to throughout the procedure (Beijing Solarbio Co., Ltd., SEKH-0565-96T; Nanjing Cusabio Biotechnology Co., Ltd., CEA186Ge, CEA185Ge).

Inflammatory markers: Serum levels of C-reactive protein (CRP), tumor necrosis factor-alpha (TNF-α), and interleukin-6 (IL-6) were analyzed via ELISA (Shanghai Zhongqiao Xinzhu Biotechnology Co., Ltd., EKH159-P, EKH218-P, EKH207-P).

Aesthetic satisfaction: A five-point satisfaction scale was used, ranging from "very satisfied" to "very dissatisfied". Total satisfaction was calculated as the sum of "very satisfied" and "satisfied" responses [18].

Statistical analysis

SPSS 18.0 was used for statistical analysis. Count data were expressed as number/percentage (n/%) for categorical variables, and comparisons between groups were performed using the χ^2 test. Continuous variables were presented as mean ± SEM, with group differences assessed using t-tests. Paired t-tests were used to evaluate changes within groups over time. A P-value of <0.05 was considered statistically significant.

Table 1. Analysis of general data

Categories	COT group (n=70)	GET group (n=80)	χ^2/t value	*P* value
Gender			0.076	0.783
Male	17 (24.29)	21 (26.25)		
Female	53 (75.71)	59 (73.75)		
Age (years old)	40.96±11.20	42.14±8.58	0.729	0.467
Tumor location			0.628	0.428
Left	28 (40.00)	27 (33.75)		
Right	42 (60.00)	53 (66.25)		
Tumor diameter (mm)	5.44±1.91	5.58±1.95	0.443	0.659
Body mass index (Kg/m^2)	24.91±3.93	24.39±3.04	0.912	0.363
Smoking history			0.936	0.333
Yes	21 (30.00)	30 (37.50)		
No	49 (70.00)	50 (62.50)		
History of alcoholism			0.061	0.805
Yes	18 (25.71)	22 (27.50)		
No	52 (74.29)	58 (72.50)		

Note: COT, conventional open thyroidectomy; GET, gasless endoscopic thyroidectomy.

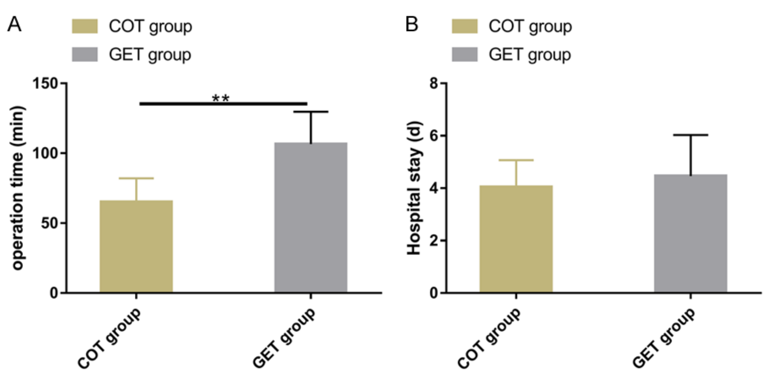

Figure 2. Analysis of surgical indicators. A. Operation time of the GET and COT groups. B. Hospital length of stay of the GET and COT groups. Note: COT, conventional open thyroidectomy; GET, gasless endoscopic thyroidectomy. ** represents P<0.01.

Results

General information

There were no statistically significant differences between the COT and GET groups in terms of sex, age, tumor location, tumor diameter, body mass index, or smoking/alcohol history (all P>0.05; **Table 1**).

Surgical efficiency

The surgical efficiency was assessed by recording OT and HLOS (**Figure 2**). The GET procedure showed a significantly longer OT (P<0.05), but similar HLOS compared to COT (P>0.05).

Clinical outcomes

IBL was significantly lower in the GET group compared to COT, while postoperative drainage on day 1 was higher in the GET group (both P<0.05). There were no significant differences between the groups in the number of central lymph nodes dissected (P>0.05) (**Figure 3**).

Clinical efficacy

Analysis of treatment efficacy demonstrated significantly better outcomes with GET compared to COT (P=0.002; **Table 2**).

Postoperative ARs

The total incidence of postoperative ARs, including temporary RLNP, POH, POI, and anterior cervical discomfort during swallowing, was significantly lower in the GET group compared to the COT group (15.00% vs. 34.29%, all P<0.05; **Table 3**).

Postoperative pain

Postoperative pain was evaluated using the VAS on the 3rd postoperative day (**Figure 4**). The GET group had significantly lower VAS scores compared to the COT group (P<0.05).

Thyroid hormones

Baseline hormone levels were comparable between the two groups (all P>0.05). Following COT, TSH levels significantly increased, surpassing both baseline and GET group levels (P<0.05). In contrast, TSH levels in the GET group remained stable, with no significant difference between pre- and post-treatment le-

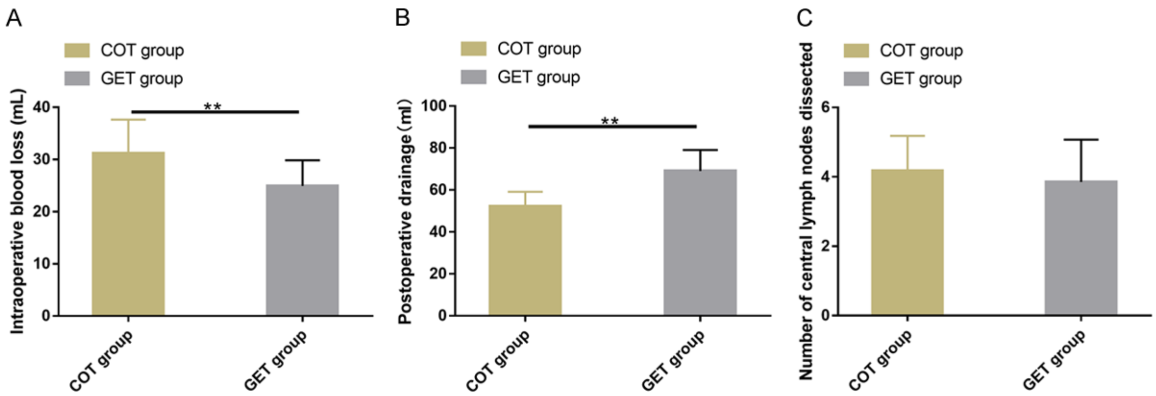

Figure 3. Analysis of clinical outcome indicators. A. Intraoperative blood loss in the GET and COT groups. B. Postoperative drainage in the GET and COT groups. C. The number of central lymph nodes dissected in the GET and COT groups. Note: COT, conventional open thyroidectomy; GET, gasless endoscopic thyroidectomy. ** represents P<0.01.

Table 2. Analysis of clinical efficacy

Efficacy	COT group (n=70)	GET group (n=80)	χ^2 value	*P* value
Markedly effective	22 (31.43)	35 (43.75)	-	-
Effective	28 (40.00)	38 (47.50)	-	-
Ineffective	20 (28.57)	7 (8.75)	-	-
Total efficacy	50 (71.43)	73 (91.25)	9.938	0.002

Note: COT, conventional open thyroidectomy; GET, gasless endoscopic thyroidectomy.

vels (P>0.05). Both groups exhibited reductions in FT3/FT4, but the GET group showed a more modest decrease than the COT group (P<0.05) (**Figure 5**).

Inflammatory factors

Pre- and postoperative (day 3) levels of CRP, TNF-α, and IL-6 were measured to assess the inflammatory response following surgery (**Figure 6**). Baseline inflammatory markers showed no significant differences between the groups (all P>0.05). Postoperatively, inflammatory indices were elevated in both groups (all P<0.05), but the GET group had significantly lower values across all measures compared to the COT group (all P<0.05).

Postoperative aesthetic satisfaction

Postoperative aesthetic satisfaction was significantly higher in the GET group compared to the COT group (90.00% vs. 68.57%, P<0.05; **Table 4**).

Discussion

Research has shown a significant increase in the incidence of PTC worldwide in recent decades, particularly for tumors smaller than 10 mm [19]. PTMC patients generally exhibit high survival rates and favorable prognosis, as most opt for active monitoring or surgical resection upon detection [20, 21]. However, there is no established consensus regarding the optimal surgical approach for PTMC. In addition to COT, various surgical techniques, including endoscopic thyroidectomy via the bilateral axillo-breast approach, transoral endoscopic thyroidectomy vestibular approach, and GET, are also utilized [22]. This study aims to analyze the clinical data of PTMC patients undergoing GET or COT, contributing to the optimization of PTMC treatment.

We first assessed the surgical efficiency of the two procedures by comparing OT and HLOS. The GET group had a significantly longer OT but similar HLOS compared to the COT group. Although the GET procedure is more complex and delicate, modifications to the technique have reduced the time required for cavity establishment, yet it still differs in OT from conventional surgery [23]. Despite the longer OT, GET did not lead to a prolonged HLOS, indicating that GET does not adversely impact recovery efficiency.

Table 3. Analysis of postoperative adverse reactions

Categories	COT group (n=70)	GET group (n=80)	χ^2 value	*P* value
Temporary recurrent laryngeal nerve paralysis	9 (12.86)	6 (7.50)	-	-
Postoperative hematoma	2 (2.86)	1 (1.25)	-	-
Postoperative infection	1 (1.43)	0 (0.00)	-	-
Postoperative anterior cervical discomfort during swallowing	12 (17.14)	5 (6.25)	-	-
Total incidence	24 (34.29)	12 (15.00)	7.613	0.006

Note: COT, conventional open thyroidectomy; GET, gasless endoscopic thyroidectomy.

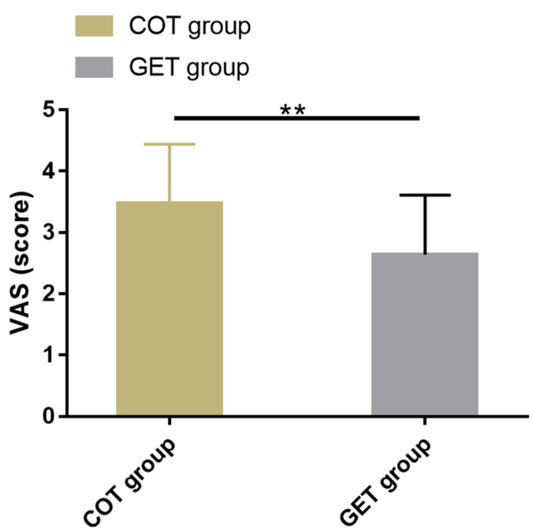

Figure 4. Analysis of postoperative pain in two groups. Postoperative VAS scores of the two patient cohorts. Note: COT, conventional open thyroidectomy; GET, gasless endoscopic thyroidectomy. ** represents P<0.01.

Next, we examined three clinical outcome measures. The GET group showed significantly lower IBL and higher postoperative drainage. The increased postoperative drainage in the GET group may be attributed to the extensive subcutaneous tissue dissection required to create the surgical space [24, 25]. Wu et al. [26] noted that inadequate lymph node dissection in PTMC treatment could elevate recurrence rates, making the number of central lymph nodes dissected an important evaluation metric. In our study, there was no significant difference between the groups in the number of central lymph nodes dissected, suggesting that both procedures are equally effective in lymph node removal. Furthermore, the GET group demonstrated a significantly higher total effective treatment rate.

Regarding postoperative ARs, the GET group had a markedly lower overall incidence of complications, such as temporary RLNP, POH, POI, and anterior cervical discomfort during swallowing, indicating a better safety profile for GET. Postoperative pain, as assessed by VAS scores on the 3rd day, was also significantly lower in the GET group, suggesting that GET is more effective in reducing postoperative pain, consistent with the findings of Yan et al. [27].

In terms of thyroid function, GET patients showed minimal variations in thyroid hormones and inflammatory markers by postoperative day 3, indicating superior thyroid function preservation and a markedly reduced inflammatory response. Aesthetic satisfaction was significantly higher in the GET group compared to the COT group, demonstrating the superior cosmetic outcomes of GET and its ability to meet patient aesthetic needs. This finding aligns with Hu et al. [28], who also reported the cosmetic advantages of GET.

There are some limitations in our study. As a single-center study, it is susceptible to information bias. Furthermore, the absence of patient follow-up restricts a comprehensive understanding of postoperative complications and the long-term effects of the two procedures on patients' quality of life. Future research will address these limitations, including a 6-12 month follow-up period to further evaluate complications and long-term outcomes.

In conclusion, GET is equally effective as COT while being safer for PTMC patients. It significantly improves postoperative aesthetic satisfaction, reduces pain, preserves thyroid function, and minimizes surgical inflammation. Given these benefits, GET is a promising approach for PTMC treatment and warrants wider clinical adoption.

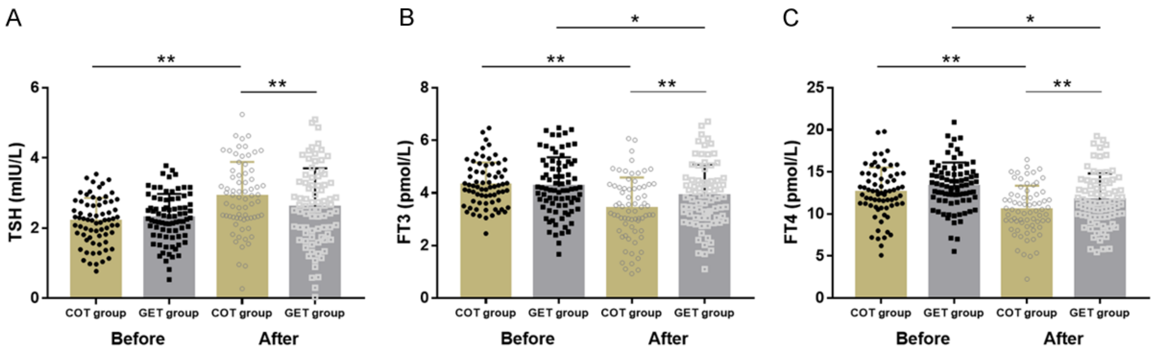

Figure 5. Thyroid hormone comparison between groups. A. Pre- and post-treatment TSH levels. B. Pre- and post-treatment FT3 levels. C. Pre- and post-treatment FT4 levels. Note: COT, conventional open thyroidectomy; GET, gasless endoscopic thyroidectomy; TSH, thyroid-stimulating hormone; FT3, free triiodothyronine; FT4, free thyroxine. *P<0.05, **P<0.05.

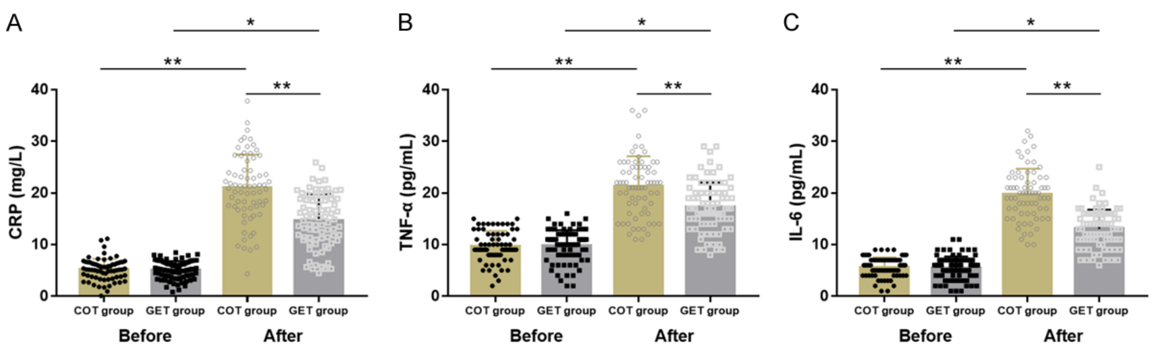

Figure 6. Analysis of inflammatory markers. A. CRP levels before and after treatment. B. TNF-α levels before and after treatment. C. Pre- and post-treatment IL-6 levels. Note: COT, conventional open thyroidectomy; GET, gasless endoscopic thyroidectomy; CRP, C-reactive protein; tumor necrosis factor-alpha; IL-6, interleukin-6. *P<0.05, **P<0.05.

Table 4. Analysis of postoperative aesthetic satisfaction

Categories	COT group (n=70)	GET group (n=80)	χ^2 value	*P* value
Very satisfied	19 (27.14)	30 (37.50)	-	-
Satisfied	29 (41.43)	42 (52.50)	-	-
Generally satisfied	20 (28.57)	7 (8.75)	-	-
Dissatisfied	2 (2.86)	1 (1.25)		
Very dissatisfied	0 (0.00)	0 (0.00)	-	-
Overall satisfaction	48 (68.57)	72 (90.00)	10.714	0.001

Note: COT, conventional open thyroidectomy; GET, gasless endoscopic thyroidectomy.

Disclosure of conflict of interest

None.

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