Article

The Impact of Minimally Invasive Video-Assisted Thyroidectomy in Thyroid Cancer Patients: Retrospective Analysis of Safety Profile and Postoperative Pain

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AIM: This study investigates the safety profile and postoperative pain in thyroid cancer (TC) patients who underwent conventional open thyroidectomy (COT) and minimally invasive video-assisted thyroidectomy (MIVAT).
METHODS: This retrospective analysis included 119 TC patients treated in our hospital between December 2018 and January 2022. Of these patients, 59 cases received COT (control group) and 60 underwent MIVAT (research group). Various surgical indices (e.g., incision length, intraoperative blood loss, stitch removal time, and hospitalization time), postoperative adverse events (hypocalcemia, secondary bleeding, incision infection, and transient postoperative swallowing discomfort based on subjective complaints), postoperative pain relief time, and degree of surgical trauma were comparatively analyzed. Furthermore, preoperative mortality and morbidity risk assessment were performed using a modified Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity (POSSUM), while postoperative pain severity was determined using the Visual Analogue Scale (VAS).
RESULTS: The research group demonstrated significantly smaller incision length ($p < 0.001$), reduced intraoperative bleeding ($p < 0.001$), shorter stitch removal time ($p < 0.001$), shorter hospitalization time ($p < 0.001$), minimal postoperative adverse event rate ($p < 0.05$), and lower modified POSSUM scores (all $p < 0.001$). However, the Glasgow Coma Scale (GCS) score showed no significant difference between the groups. Additionally, the research group exhibited lower postoperative VAS scores ($p < 0.001$) and shorter pain relief time ($p < 0.001$) than the control group.
CONCLUSIONS: Using MIVAT in TC patients contributes to favorable surgical outcomes and safety, with minimal surgical trauma and adequate postoperative pain relief, highlighting its potential for broader clinical implementation.

Keywords: minimally invasive video-assisted thyroidectomy; thyroid cancer; safety; postoperative pain

Introduction

Thyroid cancer (TC) is a heterogeneous endocrine malignancy characterized by high incidence and generally favorable overall survival [1,2]. At initial diagnosis, TC patients often present with thyroid masses, while advanced-stage disease can manifest as hoarseness, dysphagia, and other clinical features that significantly impair daily activities and quality of life [3]. The known pathogenic factors of TC include abnormal iodine intake, radiation exposure, and sex hormone imbalances [4,5]. Surgical intervention is regarded as the primary treatment option, particularly for differentiated TC subtypes (papillary and follicular), which comprise more than 90% of cases [6]. However, establishing subcutaneous passages and surgical spaces during resection can introduce varying degrees of tissue trauma, resulting in postoperative adverse reactions (ARs) such as hypocalcemia, secondary bleeding, and pain [7,8]. Therefore, developing safe, less painful surgical options is crucial for optimizing patient experience and improving long-term prognoses.

In clinical practice, conventional open thyroidectomy (COT) has shown particular efficacy; however, it requires a large cervical incision, which can lead to excessive intraoperative bleeding [9]. Additionally, COT causes significant tissue trauma, increasing the risk of surgical site infections and complications such as neck hematoma, thereby delaying postoperative recovery [10].

Minimally invasive video-assisted thyroidectomy (MIVAT) has emerged to address these limitations. This minimally invasive surgical technique uses video-assisted equipment through smaller incisions, providing surgeons with an enhanced visual field to perform more precise procedures. Compared to COT, MIVAT offers several significant advan-

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tages: a smaller incision minimizes postoperative trauma, reduces postoperative pain, and shortens recovery time; the endoscopic view enhances surgical accuracy, particularly for tumor removal and margin evaluation [11]. Additionally, MIVAT not only reduces intraoperative bleeding but also lowers the incidence of postoperative complications, such as infections and neck hematomas [12]. These advantages make MIVAT a safer and more effective surgical option for thyroid cancer patients.

Although MIVAT demonstrated advantages in minimizing trauma and improving recovery, research on its safety profile and impact on postoperative pain remains relatively limited. Therefore, this study aims to investigate safety outcomes, postoperative pain levels, and other surgical indicators between MIVAT and COT in thyroid cancer patients, providing more comprehensive clinical evidence to explore the significance of MIVAT in thyroid cancer surgery.

Methods

Study Subjects

The inclusion criteria for patient enrollment were as follows: pathologically confirmed TC, tumors confined to unilateral glandular lobe or isthmus without invading the capsule, preoperative thyroid hormone levels maintained within the normal range, patients complete clinical record, the patient willingness to comply with study procedure, and those with no history of thyroid or neck surgery. Exclusion criteria included significant dysfunction of major organs like the heart, lungs, and kidneys, presence of other malignant tumors, previous surgical history involving the head or neck, coagulation dysfunction or known autoimmune diseases, and any surgical contraindications.

Following the predetermined inclusion and exclusion criteria, 119 TC patients treated at Shanxi Bethune Hospital between December 2018 and January 2022 were enrolled. Out of these, 59 cases in the control group received COT, and 60 cases in the research group underwent MIVAT. The study protocol was approved by the Ethics Committee of Shanxi Bethune Hospital, China (YXLL-2024-124), and informed consent was obtained from all patients. This study was conducted in accordance with the principles of the Declaration of Helsinki.

Surgical Protocols

The patients in the control group underwent COT. Under general anesthesia, patients were placed in a supine position, and a 6–8 cm horizontal incision was made along the neckline. The subplatysmal flaps were elevated, and the cervical linea alba was cut to fully expose the thyroid gland. The affected thyroid lobe, isthmus and contralateral lobe were then excised, followed by central lymph node dissection. Finally, a drainage tube was placed, and the incision was closed.

Patients in the research group underwent MIVAT as follows: the patient received general anesthesia in the supine position, and the neck was hyperextended using a small pillow. Then, a 2-cm arc-shaped incision was made along the dermatoglyph of the cervical suprasternal fossa. Skin, subcutaneous tissue, platysma and anterior cervical muscles were sequentially cut using an electric knife. The cervical linea alba was open to separate the anterior cervical muscles, and a skin retractor was then inserted to stretch these muscles. A 5-mm endoscope was introduced to expose the thyroid gland and any nodules. Thereafter, the affected gland lobe and isthmus were excised, and the central lymph node area was cleaned. The residual cavity was closed with 5-0 non-invasive sutures, the surgical field was flushed, a drainage tube was placed, and the incision was closed using a non-absorbable monofilament suture (Fig. 1).

Evaluation Indexes

Patients were assessed using the following indicators:

(1) Surgical effect: Incision length, intraoperative bleeding, stitch removal time and hospitalization time were observed and recorded.
(2) Adverse reactions (ARs): The incidence of postoperative complications, such as hypocalcemia, secondary hemorrhage, surgical-site infection, and dysphagia were observed in both groups and recorded at three-time points: 24 hours, 72 hours, and immediately before discharge.
(3) Trauma evaluation: The degree of surgical trauma was assessed using the modified Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity (POSSUM) [13]. This scoring system includes 12 physiological indicators, such as heart rate, hemoglobin levels, cardiac signs, white blood cell count, and Glasgow Coma Scale (GCS) to assess preoperative patient status, alongside 6 surgical severity scoring items to evaluate intraoperative risk.
(4) Degree assessment: Pain intensity was monitored 24 hours after operation using the Visual Analogue Scale (VAS), with a score ranging from 0 (no pain) to 10 (worst pain). The postoperative pain relief time was compared between the two groups. Postoperative pain relief time was defined as the interval, in hours, from the end of surgery until the patient reported no significant pain or no longer required analgesics.

Statistical Analysis

Data were statistically analyzed using SPSS software (version 22.0, IBM Corp., Armonk, NY, USA). Furthermore, plots were generated and visualized using GraphPad Prism version 10 (GraphPad Software Inc., San Diego, CA, USA). Categorical data were expressed as the number of cases/percentage (n/%), and continuous data as mean $\pm$ standard deviation (SD). The Shapiro-Wilk test was applied to assess the normality of continuous variables. Normally distributed data was expressed as mean $\pm$ SD, with inter-

Fig. 1. Illustration of MIVAT procedure. (A) Preoperative positioning. The patient was positioned appropriately to facilitate the minimally invasive approach. (B) The affected thyroid gland lobe and isthmus were carefully resected. The central lymph node area was dissected with enhanced visualization facilitated by endoscopic technology. (C) Postoperatively, the wound was closed through a small incision, and a drainage tube was placed to prevent fluid accumulation. Closure was achieved using non-absorbable monofilament sutures to minimize scarring. MIVAT, minimally invasive video-assisted thyroidectomy.

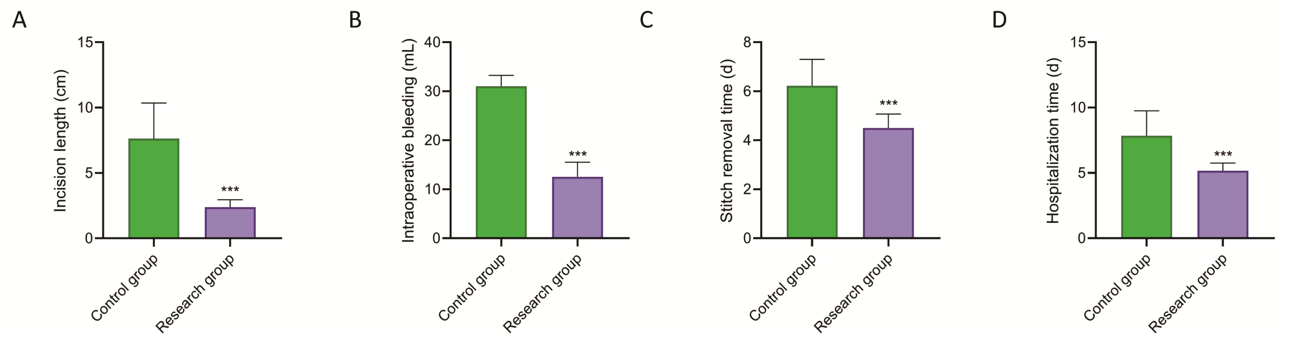

Fig. 2. Assessment of surgical indicators across the control and research groups. Comparison of (A) incision length, (B) intraoperative bleeding, (C) stitch removal time, and (D) hospitalization time between the research and control groups. Note: *** represents $p <$ 0.001 vs. the control group.

group comparisons conducted using independent sample *t*-tests. Moreover, categorical variables were analyzed using chi-square (χ^2) tests. A *p*-value less than 0.05 was considered statistically significant.

Results

Comparison of Baseline Characteristics Between the Two Groups

As detailed in Table 1, there were no significant differences between the control and research groups in baseline data: sex (male/female: 32/27 vs. 38/22), age (51.25 ± 5.11 vs. 51.73 ± 7.07), tumor location (left/right: 35/24 vs. 32/28), pathological subtype (papillary/follicular/medullary: 45/10/4 vs. 48/9/3), family history of TC (yes/no: 9/50 vs. 6/54), smoking history (yes/no: 18/41 vs. 23/37), and the history of alcoholism (yes/no: 15/44 vs. 14/46) (all $p > 0.05$). Therefore, the two groups were clinically found to be comparable at baseline characteristics.

MIVAT Improves Surgical Outcomes

Surgical outcomes were evaluated by measuring incision length, intraoperative bleeding, stitch removal time, and hospitalization time (Fig. 2). Relative to the control group, the research group showed significantly better results in all four indicators: incision length (control: 7.6 ± 2.73 vs. research: 2.4 ± 0.56, $p < 0.001$), intraoperative bleeding (control: 31 ± 2.24 vs. research: 12.6 ± 2.97, $p < 0.001$), stitch removal time (control: 6.2 ± 1.08 vs. research: 4.5 ± 0.57, $p < 0.001$), and hospitalization time (control: 7.8 ± 1.91 vs. research: 5.2 ± 0.59, $p < 0.001$). These findings indicate that the research group demonstrated superior outcomes across all four measured parameters compared to the control group ($p < 0.05$).

MIVAT Reduces the Incidence of Postoperative Complications

As summarized in Table 2, the research group demonstrated a considerably lower incidence of adverse reactions compared to the control group: hypocalcemia (8.47% vs.

Table 1. Comparison of baseline data between the two groups.

Variable	Control group (n = 59)	Research group (n = 60)	χ^2/t value	p-value
Gender			1.016	0.313
Male	32 (54.24)	38 (63.33)		
Female	27 (45.76)	22 (36.67)		
Age	51.3 ± 5.1	51.7 ± 7.1	0.424	0.672
TNM stage			0.129	0.938
T1	42	44		
T2	11	11		
T3	6	5		
Tumor location			0.434	0.510
Left side	35 (59.32)	32 (53.33)		
Right side	24 (40.68)	28 (46.67)		
Pathological subtype			0.284	0.868
Papillary carcinoma	45 (76.27)	48 (80.00)		
Follicular carcinoma	10 (16.95)	9 (15.00)		
Medullary carcinoma	4 (6.78)	3 (5.00)		
Family history of thyroid cancer			0.745	0.388
Yes	9 (15.25)	6 (10.00)		
No	50 (84.75)	54 (90.00)		
Smoking history			0.807	0.369
Yes	18 (30.51)	23 (38.33)		
No	41 (69.49)	37 (61.67)		
History of alcoholism			0.071	0.791
Yes	15 (25.42)	14 (23.33)		
No	44 (74.58)	46 (76.67)		

Note: TNM, Tumor–Node–Metastasis classification system. TNM staging was performed based on the AJCC 8th edition criteria, and all cases were staged as T1–T3 with no evidence of nodal (N0) or distant metastasis (M0).

Table 2. Comparison of postoperative adverse reactions between the two groups.

Variable	Control group (n = 59)	Research group (n = 60)	χ^2 value	p-value
Hypocalcemia	5 (8.47)	2 (3.33)	0.64	0.422
Secondary hemorrhage	4 (6.78)	2 (3.33)	0.19	0.660
Incision infection	6 (10.17)	1 (1.67)	2.50	0.114
Dysphagia	5 (8.47)	2 (3.33)	0.64	0.422
Total incidence	20 (33.90)	7 (11.67)	8.38	0.004

3.33%), secondary bleeding (6.78% vs. 3.33%), incision infection (10.17% vs. 1.67%), and dysphagia (8.47% vs. 3.33%). Overall, the rate of adverse reactions was 11.67% in the research group vs. 33.90% in the control group ($p <$ 0.05).

Preoperative Physiological Assessment in MIVAT and COT Patients Using POSSUM

Physiological indicators, including heart rate, hemoglobin, cardiac signs, wound contamination, white blood cell count, and GCS, were evaluated using the modified POSSUM physiological score, along with the surgical severity items, such as wound contamination (Fig. 3). The research group showed significantly lower scores compared to the control group for heart rate (3.6 ± 0.92 vs. 2.1 ± 0.68, $p < 0.001$), hemoglobin (2.86 ± 0.57 vs. 2.0 ± 0.45, $p < 0.001$), cardiac signs (3.6 ± 0.89 vs. 2.3 ± 0.58, $p < 0.001$), wound contamination (5.2 ± 1.31 vs. 3.3 ± 0.75, $p < 0.001$), and white blood cell count (3.0 ± 0.66 vs. 2.0 ± 0.49, $p <$ 0.001). However, no significant difference was observed in GCS scores ($p = 0.466$); the median score was 10.0 (IQR: 9.0–11) in group 1 and 9.0 (IQR: 9.0–11.0) in group 2. These results suggest that the research group had favorable preoperative physiological status compared to the control group, particularly regarding heart rate, hemoglobin, and cardiac signs.

MIVAT Improves the Postoperative Pain

By evaluating the VAS and postoperative pain relief time of both groups, the effects of the two surgical modalities on postoperative pain were compared and analyzed (Fig. 4). The research group showed substantially lower VAS scores (5.7 ± 1.84 vs. 2.9 ± 0.86, $p < 0.001$) and shorter postoperative pain relief time (6.1 ± 1.00 vs. 3.8 ± 0.60, $p < 0.001$)

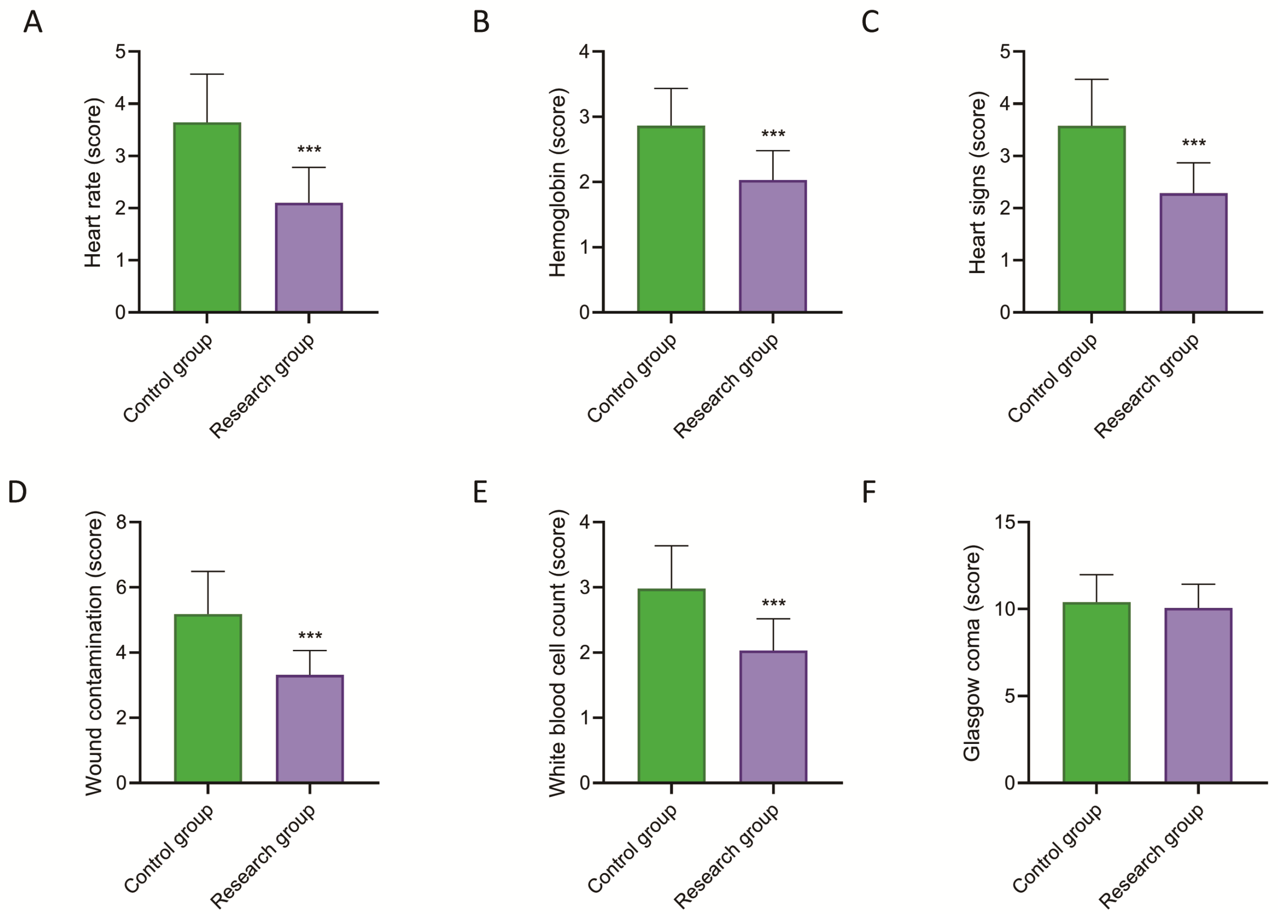

Fig. 3. Analysis of preoperative physiological parameters across the two groups. Comparison of (A) heart rate, (B) hemoglobin, (C) cardiac signs, (D) wound contamination, (E) white blood cell count, (F) GCS sores between the two groups. GCS scores for the two groups were based on their original preoperative values rather than the POSSUM-assigned values. Note: *** represents $p < 0.001$ vs. the control group. POSSUM, Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity; GCS, Glasgow Coma Scale.

compared to the control group. These results indicate that patients in the research group experienced significantly less postoperative pain and achieved quicker pain relief.

Discussion

The incidence of TC has steadily increased over recent decades, making it the second most frequently diagnosed malignancy during pregnancy and the postpartum period, following breast cancer [14]. Surgical intervention remains the primary treatment option for TC; however, individuals over 65 years old are at higher risk for postoperative complications, which can adversely affect clinical outcomes [15]. Moreover, 70% of TC-related deaths occur in this age group [16]. Therefore, it is necessary to explore surgical safety in TC. This study focuses on MIVAT as a potentially safer surgical modality, aiming to improve patients' prognoses.

Among 119 TC patients divided into the control (COT) and research (MIVAT) groups, surgical outcomes were initially analyzed. The research group demonstrated substantially lower incision length, reduced intraoperative bleeding, faster stitch removal time, and shorter hospital stays than the control group, underscoring MIVAT's advantages in reducing blood loss and improving wound healing. The shorter incision length and lower tissue disruption during endoscopy-guided thyroid surgery are likely to underlie these improvements, thereby facilitating faster postoperative recovery. Furthermore, five physiological parameters, including heart rate, hemoglobin, and white blood cell count, were compared between the two groups. The research group exhibited lower values, suggesting a milder overall physiological stress response, which might be due to the less invasiveness of the MIVAT procedure. These findings support our assumption that MIVAT minimizes surgical trauma and accelerates postoperative recovery. Consistent with our findings, Jian *et al.* [17] also reported that MIVAT results in less trauma than other thyroidectomy approaches.

Additionally, postoperative pain and pain relief time were assessed in both cohorts. The research group showed a substantially lower VAS score and shorter pain relief time than

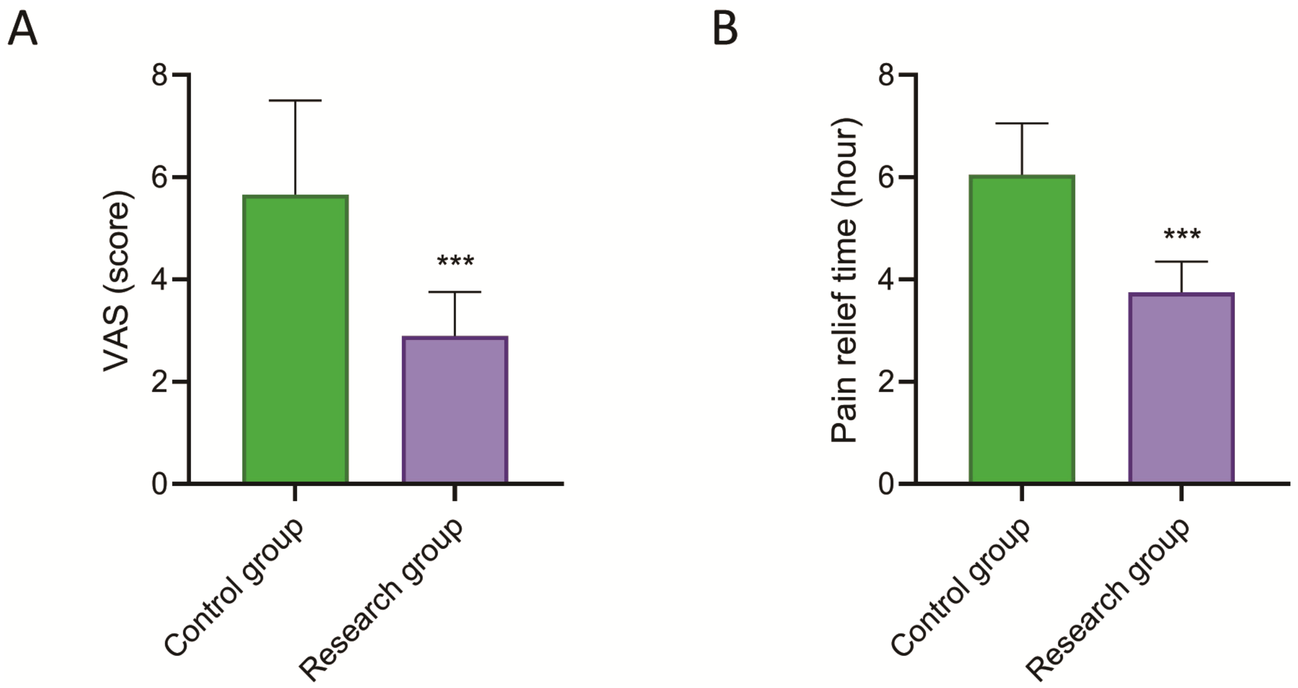

Fig. 4. Postoperative pain assessment across the two groups. Comparison of postoperative (A) VAS scores and (B) pain relief time between the two groups. Note: *** represents $p < 0.001$ vs. the control group. VAS, Visual Analogue Scale.

the control group, suggesting that MIVAT effectively alleviates postoperative discomfort in TC. Similarly, Zhang *et al*. [18] reported significant pain reduction after endoscopic thyroidectomy, supporting our findings. Given the high risk of postoperative complications, including dysphagia and surgical-site infection [19], we monitored postoperative AR rate in the research versus the control group (11.67% < 33.90%), indicating that MIVAT offers a safer profile for patients with TC. These observations are consistent with the results of Xu *et al*. [20], who evaluated thyroid tumor procedures and reported similar outcomes.

This study did not directly compare COT and MIVAT in terms of achieving tumor-free margin (R0 resection). However, all postoperative specimens were pathologically examined and were found to be tumor negative. The enhanced visualization provided by endoscopic technology in MIVAT may improve margin control. Nevertheless, the current study did not quantitatively compare MIVAT and COT in ensuring tumor-free margins (R0 resection), nor did it offer intraoperative images to validate this potential advantage. Future studies should evaluate R0 resection rates between these two surgical methods using intraoperative imaging, margin-specific pathology, and postoperative follow-up information. These analyses would provide stronger clinical evidence, particularly in terms of MIVAT's capacity to accurately excise tumors and reduce the risk of R1 resection. Incorporating imaging data and detailed margin records in future investigations will help quantify the relative effectiveness of MIVAT and COT in achieving tumor-free margins (R0 resection).

This study primarily focused on short-term outcomes, such as postoperative pain and complications, MIVAT's advantages in reducing trauma, minimizing complications, and accelerating recovery, highlighting the need for investigation of its impact on long-term outcomes, including recurrence rates and overall survival. Improved short-term outcomes may lead to enhanced long-term prognosis and lower recurrence risk, especially if integrated with more frequent follow-up for early detection. Therefore, future studies should include extended follow-up of MIVAT and COT patients to assess recurrence, disease-free survival, and overall survival, as well as evaluating quality of life and functional outcomes to provide further insights into MIVAT's potential benefits.

Despite several promising outcomes, we acknowledge certain limitations in this study. Uniform clinical staging data were not consistently available and were not included in the retrospective analysis, limiting the ability to assess the impact of tumor stage on surgical outcomes. Moreover, postoperative pain was assessed using the VAS score at 24 hours post-surgery, which does not capture temporal fluctuations in pain intensity. Incorporating pain assessment at multiple time points (e.g., 48 and 72 hours) would offer a more comprehensive understanding of MIVAT's impact on pain reduction and recovery. In summary, while this study highlights MIVAT's short-term advantages, future investigations are required to evaluate its long-term clinical efficacy.

Conclusions

Our findings demonstrate that MIVAT outperforms COT by delivering better surgical outcomes in TC: it significantly reduces the incidence of postoperative adverse events, improves procedural safety, and lowers surgical trauma, thereby alleviating postoperative pain and pain relief time. These advantages highlight MIVAT's potential for wider clinical adoption. However, future studies should address the long-term outcomes and optimize approaches for tumor margin control to provide a more comprehensive understanding of MIVAT's efficacy.

Availability of Data and Materials

The labeled dataset used to support the findings of this study are available from the corresponding author upon request.

Author Contributions

JZ, Conceptualization, Formal Analysis, Writing - Original Draft, Writing - Review and Editing; XZZ, Methodology, Formal Analysis, Writing - Original Draft, Writing - Review and Editing; JW, Data curation, Writing - Review and Editing; JLH, Conceptualization, Methodology, Writing - Review and Editing, Project administration, Funding acquisition. All authors contributed to important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study protocol was approved by the Ethics Committee of Shanxi Bethune Hospital, China (YXLL-2024-124) and was conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent prior to their inclusion in the study.

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Conflict of Interest

The authors declare no competing interests.

References

[1] Huang K, Wang N, Huang X, Qian S, Cai Y, Wu F, *et al*. Global, regional, and national burden of thyroid cancer in young people aged 10-24 years from 1990 to 2021: an analysis based on the Global Burden of Disease Study 2021. BMC Public Health. 2025; 25: 1221. https://doi.org/10.1186/s12889-025-22322-1.

[2] Yang H, Park H, Ryu HJ, Heo J, Kim JS, Oh YL, *et al*. Frequency of TERT Promoter Mutations in Real-World Analysis of 2,092 Thyroid Carcinoma Patients. Endocrinology and Metabolism (Seoul, Korea). 2022; 37: 652–663. https://doi.org/10.3803/EnM.2022.1477.

[3] Zhang J, Fu C, Cui K, Ma X. Papillary thyroid carcinoma with tracheal invasion: A case report. Medicine. 2019; 98: e17033. https://doi.org/10.1097/MD.0000000000017033.

[4] Maleki Z, Hassanzadeh J, Ghaem H. Relationship of modifiable risk factors with the incidence of thyroid cancer: a worldwide study. BMC Research Notes. 2025; 18: 22. https://doi.org/10.1186/s13104-024-07058-2.

[5] Akhavan-Mahdavi A, Yekta M, Shafiei S, Darbari SM, Zakavi SR, Emadzadeh M, *et al*. Effects of radioactive iodine therapy on female sex hormones and menstrual cycle in patients with differentiated thyroid carcinoma. Clinical and Translational Imaging. 2025; 13: 65–71. https://doi.org/10.1007/s40336-024-00667-8.

[6] Beckham TH, Romesser PB, Groen AH, Sabol C, Shaha AR, Sabra M, *et al*. Intensity-Modulated Radiation Therapy With or Without Concurrent Chemotherapy in Nonanaplastic Thyroid Cancer with Unresectable or Gross Residual Disease. Thyroid. 2018; 28: 1180–1189.

[7] Zanghì A, Cavallaro A, Di Vita M, Cardì F, Di Mattia P, Piccolo G, *et al*. The safety of the Harmonic® FOCUS in open thyroidectomy: a prospective, randomized study comparing the Harmonic® FOCUS and traditional suture ligation (knot and tie) technique. International Journal of Surgery (London, England). 2014; 12 Suppl 1: S132–5. https://doi.org/10.1016/j.ijsu.2014.05.028.

[8] Sun P, Zhan J, Chong TH, Li J, Wang C. Endoscopic central lymph node dissection of thyroid cancer via chest-breast approach: results, indications, and strategies. Surgical Endoscopy. 2022; 36: 4239–4247. https://doi.org/10.1007/s00464-021-08758-7.

[9] Jiang WJ, Yan PJ, Zhao CL, Si MB, Tian W, Zhang YJ, *et al*. Comparison of total endoscopic thyroidectomy with conventional open thyroidectomy for treatment of papillary thyroid cancer: a systematic review and meta-analysis. Surgical Endoscopy. 2020; 34: 1891–1903. https://doi.org/10.1007/s00464-019-07283-y.

[10] Yuan Y, Sun C, Yin T, Shao C, Pan B, Lu D, *et al*. Comparison of endoscopic thyroidectomy by complete areola approach and conventional open surgery in the treatment of differentiated thyroid carcinoma: A retrospective study and meta-analysis. Frontiers in Surgery. 2022; 9: 1000011. https://doi.org/10.3389/fsurg.2022.1000011.

[11] Scerrino G, Melfa G, Raspanti C, Rotolo G, Salamone G, Licari L, *et al*. Minimally Invasive Video-Assisted Thyroidectomy: Analysis of Complications From a Systematic Review. Surgical Innovation. 2019; 26: 381–387. https://doi.org/10.1177/1553350618823425.

[12] Miccoli P, Fregoli L, Rossi L, Papini P, Ambrosini CE, Bakkar S, *et al*. Minimally invasive video-assisted thyroidectomy (MIVAT). Gland Surgery. 2020; 9: S1–S5. https://doi.org/10.21037/gs.2019.12.05.

[13] Ihnsook J, Myunghee K, Jungsoon K. Predictive accuracy of severity scoring system: a prospective cohort study using APACHE III in a Korean intensive care unit. International Journal of Nursing Studies. 2003; 40: 219–226. https://doi.org/10.1016/s0020-7489(02)00062-7.

[14] Danehy TL, Manavalan A, Schechter C, Tomer Y. 7079 Analysis of the association between recent exposure to pregnancy and the histological subtype of thyroid cancer. Journal of the Endocrine Society. 2024; 8: bvae163–1897. https://doi.org/10.1210/jendso/bvae163.1897.

[15] Papaleontiou M, Hughes DT, Guo C, Banerjee M, Haymart MR. Population-Based Assessment of Complications Following Surgery for Thyroid Cancer. The Journal of Clinical Endocrinology and Metabolism. 2017; 102: 2543–2551. https://doi.org/10.1210/jc.2017-00255.

[16] Papaleontiou M, Norton EC, Reyes-Gastelum D, Banerjee M, Haymart MR. Competing Causes of Death in Older Adults with Thyroid Cancer. Thyroid: Official Journal of the American Thyroid Association. 2021; 31: 1359–1365. https://doi.org/10.1089/thy.2020.0929.

[17] Jian CX, Wu LM, Zheng ZF, Liu W, Fang JY, Tu HJ. How Should the Surgical Approach In Thyroidectomy Be Selected? A Prospective Study Comparing the Trauma of 3 Different Thyroidectomy Surgical Approaches. Surgical Laparoscopy, Endoscopy & Percutaneous Techniques. 2020; 30: 22–25. https://doi.org/10.1097/SLE.0000000000000743.

[18] Zhang D, Wan L, Frattini F, Dionigi G. Increased acute-phase reaction after the transoral endoscopic thyroidectomy vestibular approach (TOEVA) compared with minimally invasive video-assisted thyroidectomy (MIVAT) for unilateral thyroidectomy. Surgery Today. 2025; 55: 969–976. https://doi.org/10.1007/s00595-024-02982-z.

[19] Wang JJ, Huang TY, Wu CW, Lin YC, Tseng HY, Liu CH, *et al*. Improving Voice Outcomes After Thyroid Surgery - Review of Safety Parameters for Using Energy-Based Devices Near the Recurrent Laryngeal Nerve. Frontiers in Endocrinology. 2021; 12: 793431. https://doi.org/10.3389/fendo.2021.793431.

[20] Xu J, Liao K, Luo Y. Clinical Study of Three Dimensional Endoscopic Technique in the Treatment of Thyroid Neoplasm. Journal of Laparoendoscopic & Advanced Surgical Techniques. Part a. 2018; 28: 1003–1007. https://doi.org/10.1089/lap.2017.0689.