A Retrospective Meta-Analysis Study of Trans-axillary Hemithyroidectomy Versus Conventional Hemithyroidectomy: Surgical Efficacy and Safety

Moatasum Hussein Hamed, MSc;[1] Sameh Abdullah, MD;[2] Alaa Mohamed El-Erian, MD;[1] Ahmed Nabil El-Hoofy, MD;[2] Mohamed Ahmed El-Shimy, MD;[2] Mohamed Samir El-Sebaie, MD[3]

[1]Department of General & Endocrine Surgery, National Institute of Endocrinology, Cairo, Egypt
[2]Department of General & Bariatric Surgery, Ain Shams University, Cairo, Egypt
[3]Department of General & Endocrine Surgery, Ain Shams University, Cairo, Egypt

Introduction: Thyroid disease is common among women and increasingly prevalent globally. Surgery is often required, with open thyroidectomy being the gold standard. However, cosmetic dissatisfaction from cervical scars has led to interest in endoscopic alternatives. Since Gagner's first endoscopic procedure, non-cervical techniques like trans-axillary thyroidectomy have gained attention for hiding scars and improving quality of life.

Aim of work: We aimed to compare trans-axillary hemithyroidectomy and traditional open surgical approach from the available literature regarding operative difficulties, feasibility, complication (intra -and post-operative), post-operative pain and cosmesis.

Patients and methods: This systematic review and meta-analysis has been performed on seven papers in accordance with the Cochrane Collaboration standards and adhered to the PRISMA declaration (Preferred Reporting Items for Systematic Reviews and Meta-analyses).

Results: The endoscopic thyroidectomy group had significantly lower blood loss (MD = 1.29, 95% CI [0.32, 2.25], $p = 0.009$) compared to the open group, while the open group had a significantly shorter operative time (MD = 37.6, 95% CI [42.77, 32.44], $p < 0.00001$). Insignificant variations have been detected in pain following surgery, hospital stay, post-operative hematoma, or vocal cord paralysis. However, endoscopic thyroidectomy was superior in cosmetic satisfaction (MD = 7.05, 95% CI [13.23, 0.88], $p = 0.03$), despite of high heterogeneity ($I^2 = 98\%$). Heterogeneity was low for most outcomes but significant for operative time ($I^2 = 82\%$) and hospital stay ($I^2 = 68\%$).

Conclusion: Trans-axillary endoscopic thyroidectomy is a safe and effective alternative with superior cosmetic outcomes. Technique selection should consider clinical factors and patient preferences.

Key words: Trans-axillary hemithyroidectomy, conventional hemithyroidectomy, endoscopic thyroidectomy, surgical efficacy, safety.

Introduction

Thyroid cancer is one of the most common malignant tumors in females, with a continuously increasing incidence worldwide over the last few decades. Mostly occurring in young to middle-aged females being the 5th most common cancer among women, concerns about appearance and quality of life (QOL) after surgery prompt exploration of operations with non-cervical approaches.[1]

Endoscopic thyroidectomy has a certain priority in terms of aesthetic effect and postoperative quality of life, so it is generally considered as a cosmetic advantage for management of benign conditions. However, as it is still a new treatment method for patients with malignant tumors, the safety and radicality should be confirmed.[2]

The safety and radical effectiveness of endoscopic or laparoscopic surgery in the treatment of malignancies in other organs has been demonstrated, with no difference in recurrence rates and survival between traditional open surgery and endoscopic or laparoscopic surgery.[3]

Many types of endoscopic thyroidectomy have been developed and applied to achieve a better cosmetic effect and reduce the invasiveness. Although the endoscopic equipment facilitates fine dissection in a magnified vision, the movements of the endoscopic instruments are limited under the endoscope.[4]

Trans axillary approach among the endoscopic thyroid surgeries is one of the most widely used methods, it hides the incision in the natural fold of the axillary skin, has better cosmetic results

DOI: 10.21608/asjs.2025.397277.1214

than other methods, and is more feasible in the identification of the recurrent laryngeal nerve and the parathyroid gland, as well as the manipulation of the upper pole of the thyroid. In trans axillary endoscopic thyroidectomy, inflatable or airless techniques are used to maintain operating space.[5]

It is important to acknowledge that endoscopic thyroid surgeries are not uniformly "minimally invasive" and do not universally reduce invasiveness. While they offer advantages in terms of cosmesis and surgical complication reduction, these advantages may not be consistently realized in every case.[6]

Generally, Endoscopic surgeries, while typically associated with reduced scarring and fewer complications, can, in certain circumstances, present a unique challenge. For example, the use of unconventional entry sites can increase the risk of injury to critical nerves, such as brachial plexus injury with the axillary approach.[7]

Aim of work: This study aimed to compare trans-axillary hemithyroidectomy and traditional open surgical approach from the available literature as regards operative difficulties, feasibility, complication (intra -and post-operative), post-operative pain and cosmesis.

Patients and methods

This systematic review and meta-analysis were conducted on 7 studies according to the guidelines by the Cochrane Collaboration reporting followed the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-analyses).

Search strategy

We searched electronic databases (PubMed, Web of Science, and the Cochrane library) with the following keywords: Trans-axillary Hemithyroidectomy, Conventional Hemithyroidectomy, Endoscopic Thyroidectomy Surgical Efficacy, Safety.

Two authors independently screened the titles and abstracts of the search results. After deleting duplicate articles, the resulting studies were reviewed against the inclusion criteria. The full texts of all studies of possible relevance were obtained for assessment against the stated inclusion criteria. Only studies that fulfilled the criteria were further assessed to synthesize the results. The reference list of the included articles was assessed for any studies that fulfilled the inclusion criteria.

Inclusion criteria: Articles included in our study encompassed full-text, English-language randomized controlled trials (RCTs), cohort studies, cross-sectional studies, and mixed-method articles that evaluated the surgical efficacy and safety of trans-axillary hemithyroidectomy compared to conventional hemithyroidectomy. The types of studies incorporated were cohort studies, RCTs, case-control studies, systematic reviews, and meta-analyses. Participants were patients aged 18 to 60 years undergoing hemithyroidectomy for benign or malignant thyroid conditions, irrespective of gender.

Exclusion criteria: We excluded investigations such as reviews, books, or commentaries, as well as studies that did not explicitly focus on comparing trans-axillary hemithyroidectomy to conventional hemithyroidectomy. Additionally, case reports, editorials, non-peer-reviewed articles, and studies involving patients with a history of previous thyroid surgery or concurrent neck surgeries were not included.

Data extraction: Data on sample size, patient characteristics, surgical outcomes, complications, and follow-up duration will be extracted.

Statistical considerations: Statistical analysis was performed using random-effects models, and heterogeneity will be assessed with the I^2 statistic.

Results

In our initial exploration across four databases, we identified 412 research studies. Upon removing duplicate studies, 202 distinct articles undergo subsequent evaluation. This evaluation process involved titles and abstracts, leading to the identification of 35 studies for comprehensive full-text assessment. Finally, seven studies aligned with the established inclusion criteria. A visual representation of this selection process is presented in the PRISMA flowchart in **(Fig. 1).**

Our systematic review and meta-analysis encompassed seven studies, including 1263 patients approximately. Our included studies' geographic distributions are china, brazil and Lithuania. The baseline summary and characteristics for the included studies are illustrated in **Table 1.**

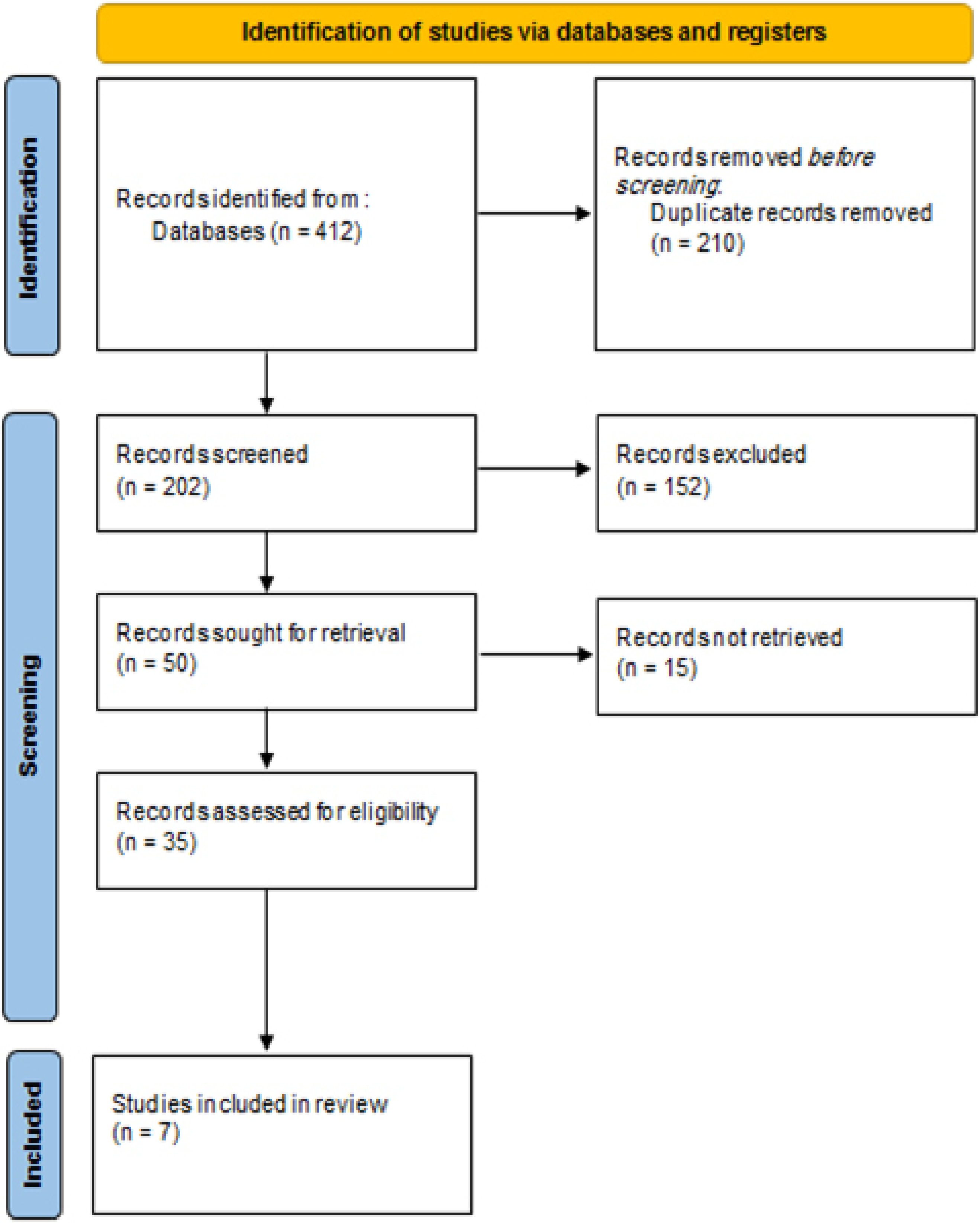

Fig 1: PRISMA flow chart for selection of included studies.

Table 1: Summary of characteristic of included studies

Study ID	Site	Study design	sample size	Sample size		BMI (kg/m2)	age
				OT	ET		
Cong.[8]	China	Retrospective cohort	51 (49F/2M)	1	50	NR	35
Jasaitis.[9]	Lithuania	Prospective	40 (40 F/0M)	0	40	23	32
LI.[10]	China	Comparative clinical	202	101(22M/79F)	101 (14M/87F)	OT 23.7/ET 21.7	34 (OT 52)
Liu.[11]	China	Case control	152	110 (38M /72F)	42 (10M /32F)	OT 24.05 /ET 23.7	NR
Xu.[12]	China	Prospective observational	134	66	68	22.2 OT /ET 20.7	36.7 (OT 9.1)
Zhang.[13]	Brazil	Retrospective cohort	185	103 (79F/24M)	82 (12M/ 70F)	OT 25.6 /ET 23.2	34.6 (OT 45)
Ding.[14]	China	Retrospective cohort	466	394 (223F/171M	72 (55F/17M)	OT 23.9 /ET 23.5	36.9 (OT 48.3)

Risk of bias assessment: Most of our included studies had a good quality, ROB1 tool showed that Liu et al.[11] had an overall low risk of bias, and most of our studies were low risk regarding selection bias and reporting bias. Risk of bias assessment graphs are provided in **(Figs. 2-3).**

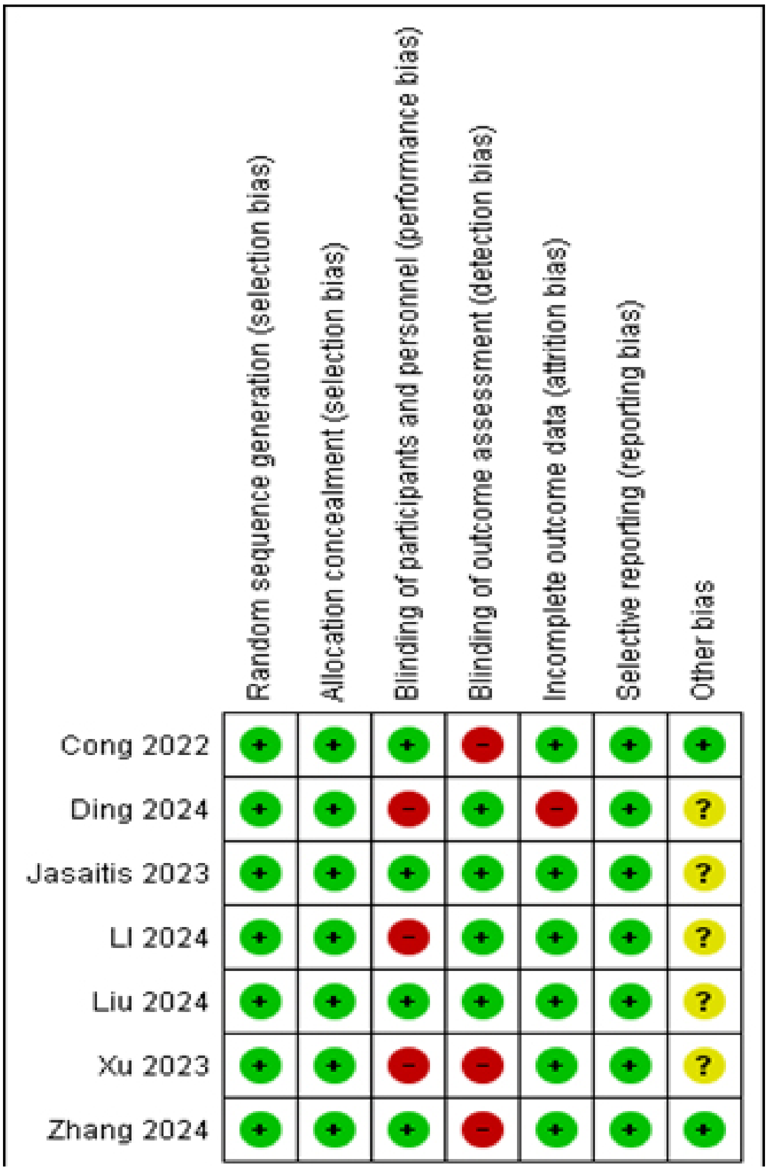

Fig 2: Risk of bias assessment for each included study.

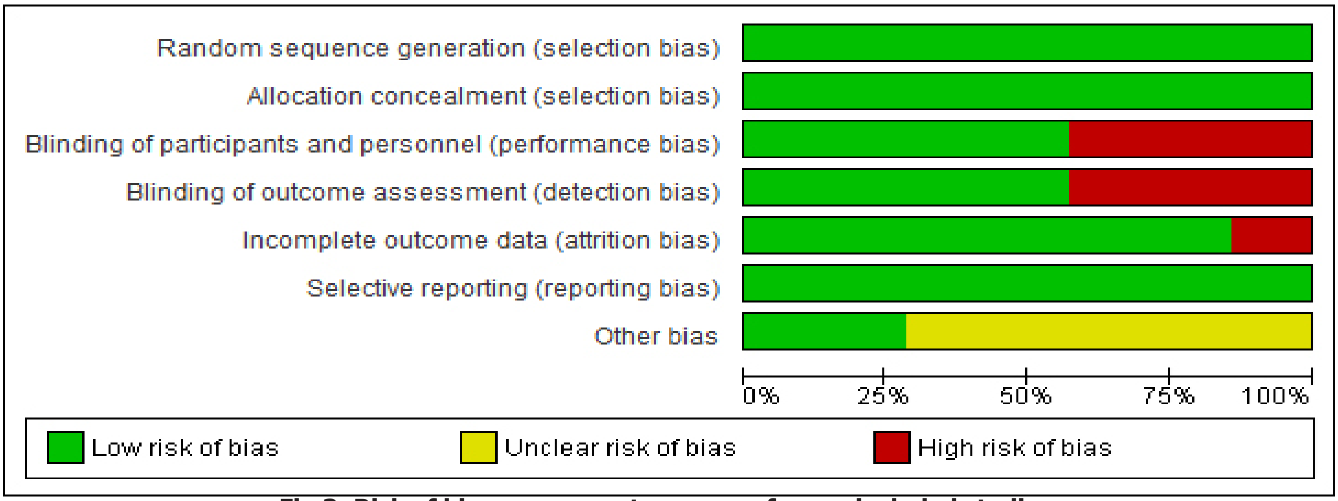

Fig 3: Risk of bias assessment summary for our included studies.

Outcomes

1. Blood loss (ml): Regarding the blood loss, it was evaluated in two studies. statistically significant lower blood loss was observed in the endoscopic group than open groups. The M.D for the blood loss was 1.29, with a 95% C.I; of [0.32, 2.25], yielding a p-value of 0.009. moderate heterogeneity was observed among the pooled studies for this outcome; I2 and Chi2-p = (66%, < 0.09). the forest plot for blood loss was presented in **(Fig. 4)**.

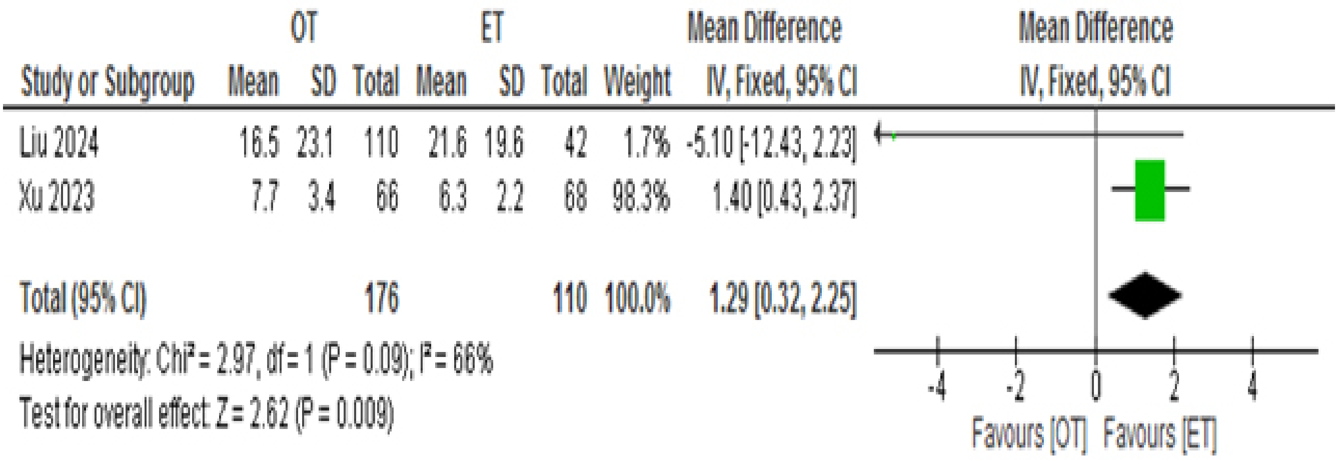

Fig 4: Forest plot for blood loss.

2. Operative time (min): Regarding the operative time, it was evaluated in four studies. statistically significant shorter operative time was observed in the open group than the endoscopic groups. Our meta-analysis resulted in the M.D for the operative time was 37.6, with a 95% C.I; of [42.77, 32.44], yielding a p-value <0.00001. major heterogeneity was observed among the pooled studies for this outcome; I^2 and Chi^2-p = (82%, < 0.0008). the forest plot for operative time was presented in **(Fig. 5).**

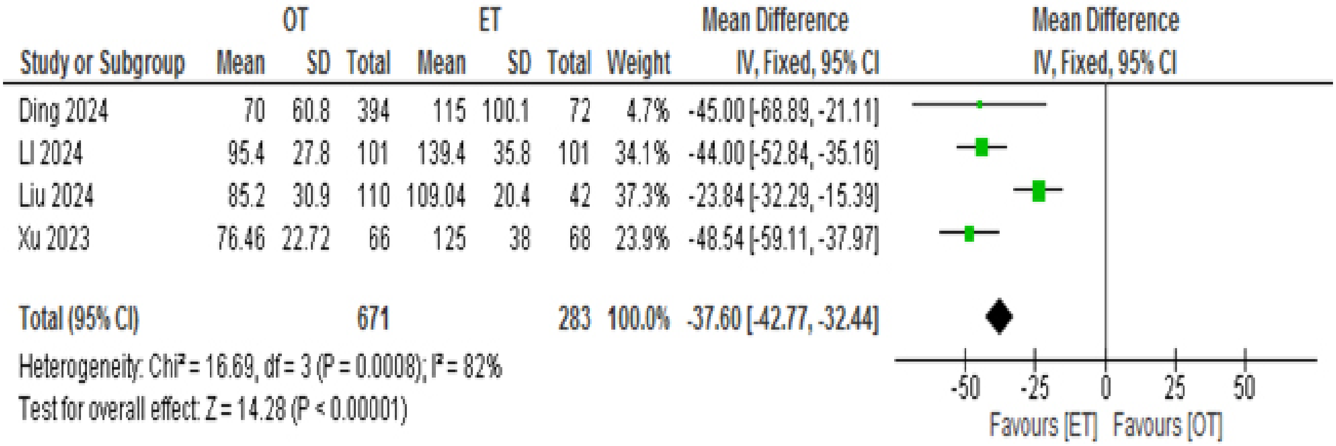

Fig 5: Forest plot for operative time.

3. Post-operative Pain: Post-operative pain was evaluated in two studies. Our pooled MDs showed no significant difference in open thyroidectomy compared to the endoscopic thyroidectomy. MDs and 95% C.I: 0.21 [0.77, 0.35], yielding a p-value = 0.47. The pooled studies were homogenous, with a Chi²-p-value of 0.98 and an I² value of 0%. The forest plot for this outcome is shown in **(Fig. 6).**

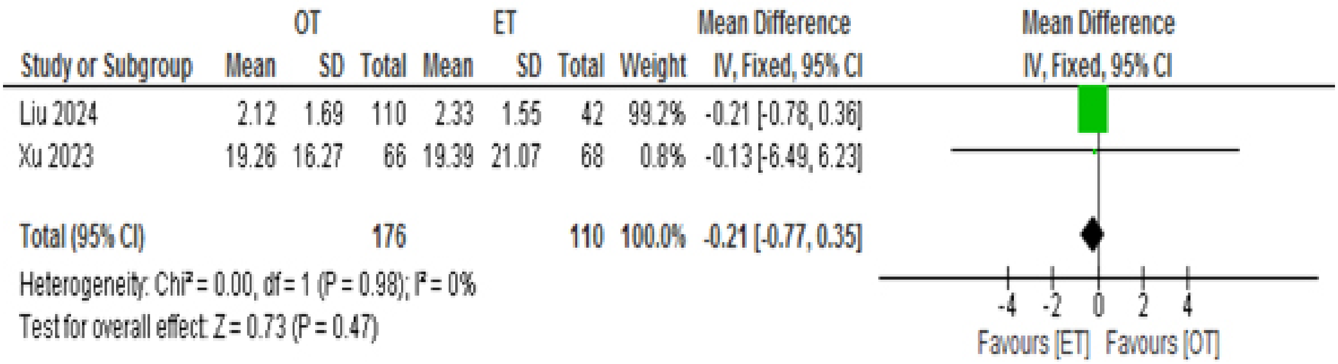

Fig 6: The forest plot for Post-Operative Pain.

4. Hospital stay (days): Hospital stay was evaluated in three studies. Our pooled MDs showed no significant difference in open thyroidectomy compared to the endoscopic thyroidectomy. MDs and 95% C.I.: 0.1[0.41, 0.2], p =0.5. The pooled studies showed major heterogenity, with a Chi²-p-value < 0.03 and an I² value of 68%. The forest plot for this outcome is shown in **(Fig. 7).**

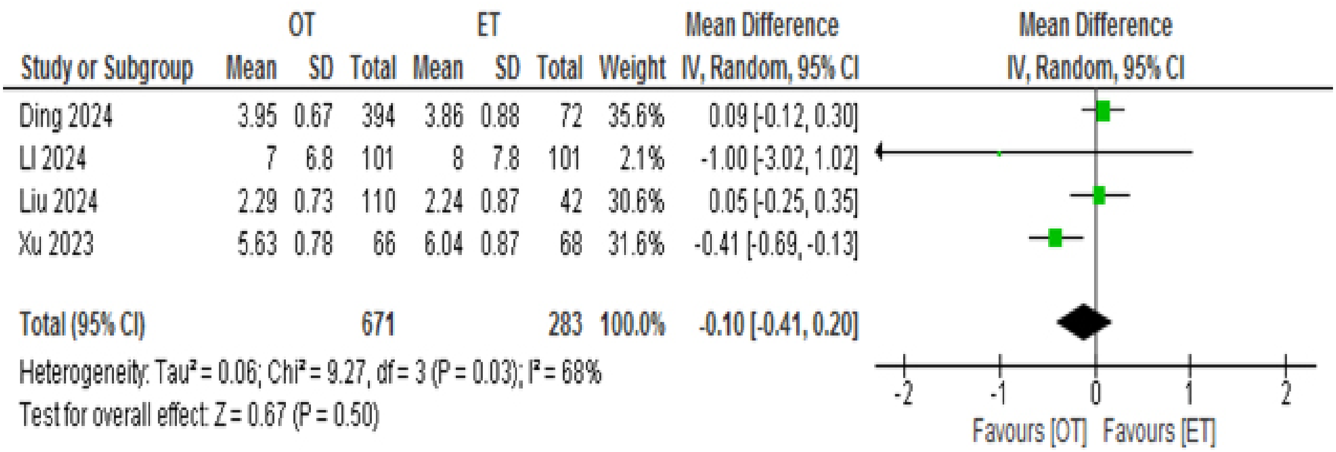

Fig 7: The forest plot for Hospital stay.

Complications

5. **Post-operative hematoma:** Post-operative hematoma was evaluated in two studies. Our pooled R.R. showed no significant difference in open thyroidectomy compared to the endoscopic thyroidectomy. R.R. and 95% C.I.: 0.77 [0.15, 3.89], p = 0.75. The pooled studies were homogenous, with a Chi^2-p-value of 0.55 and an I² value of 0%. The forest plot for this outcome is shown in **(Fig. 8)**.

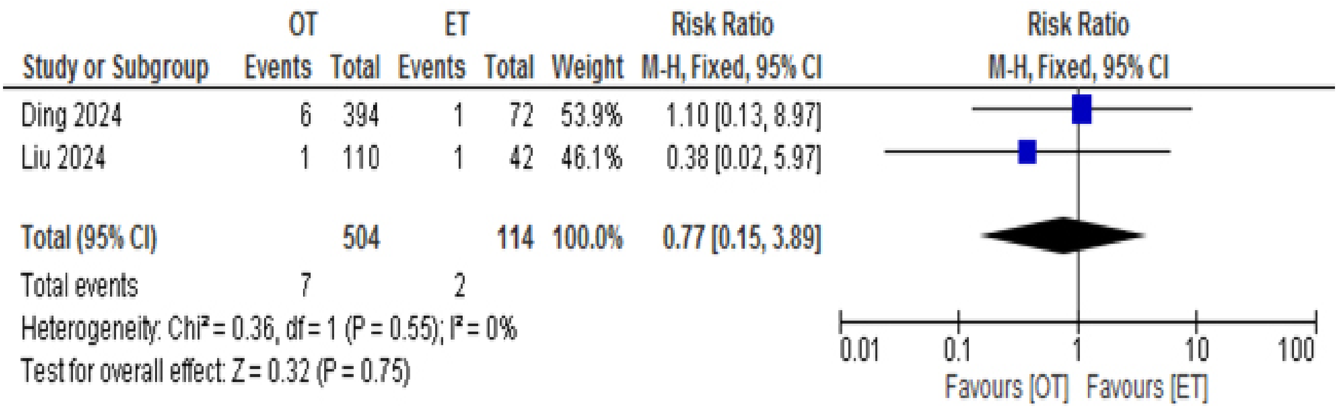

Fig 8: Forest plot for post-operative hematoma.

6. Temporary vocal cord paralysis: Temporary vocal cord paralysis was evaluated in four studies. Our pooled R.R. showed no significant difference in open thyroidectomy compared to the endoscopic thyroidectomy. R.R. and 95% C.I.: 0.94 [0.61, 1.47], p =0.8. The pooled studies were homogenous, with a Chi^2-p-value of 0.62 and an I² value of 0%. The forest plot for this outcome is shown in **(Fig. 9).**

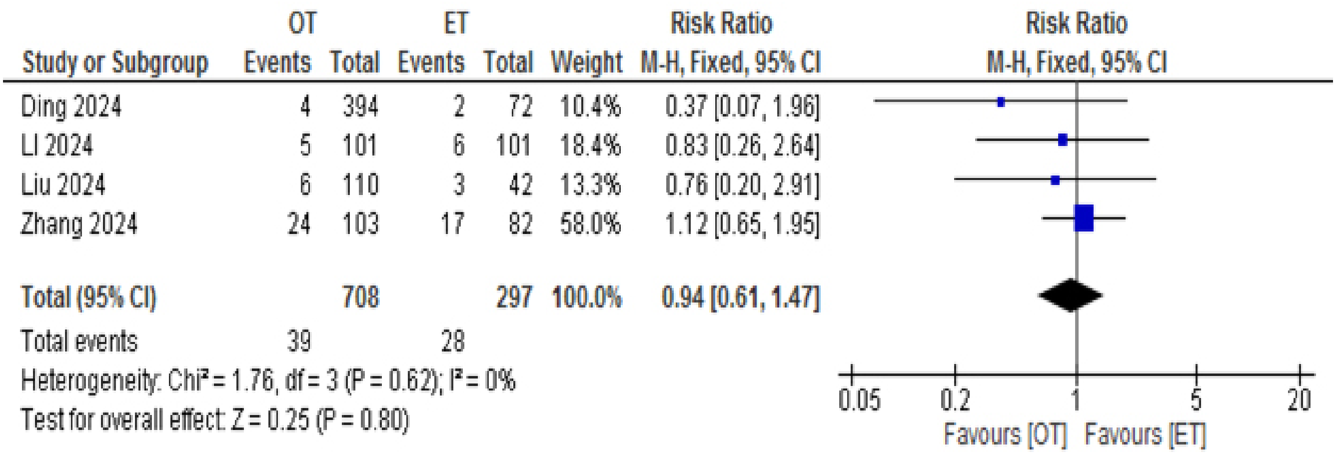

Fig 9: The forest plot for temporary vocal cord paralysis.

7. Permanent vocal cord paralysis: It was evaluated in two studies. Our pooled R.R. showed no significant difference in open thyroidectomy compared to the endoscopic thyroidectomy. R.R. and 95% C.I.: 0.13 [0.01, 3.11], p =0.2. The forest plot for this outcome is shown in **(Fig. 10).**

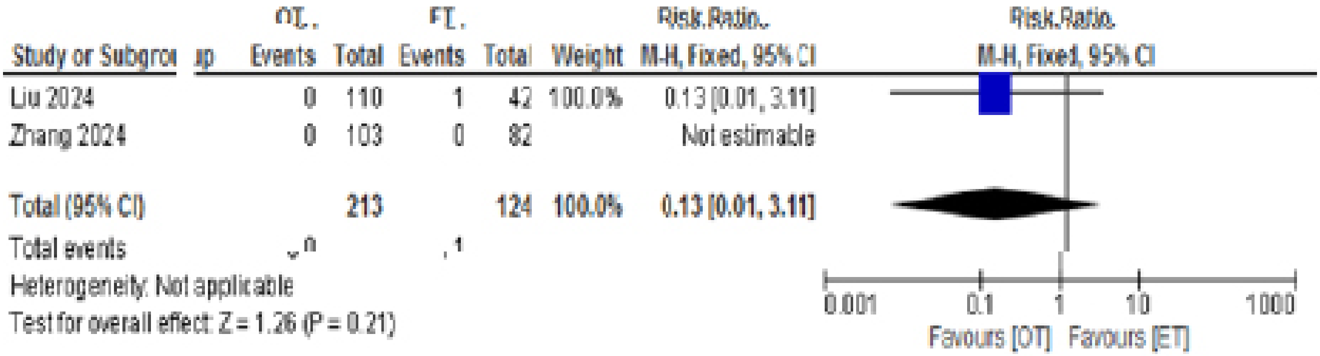

Fig. 10: The forest plot for Permanent vocal cord paralysis...

8. Cosmetic satisfaction: Regarding cosmetic satisfaction, it was evaluated in three studies our meta-analysis showed that endoscopic thyroidectomy is superior to open thyroidectomy in cosmetic results, the pooled MD and 95%CI; 7.05[13.23, 0.88], p-value=0.03. individually each of our three studies was measured by different scale which was responsible for the major heterogeneity detected upon our meta-analysis I^2 98% and chi-p 0.000001 random effect model was applied to overcome heterogeneity. **(Fig. 11)** represents forest plot for cosmetic satisfaction.

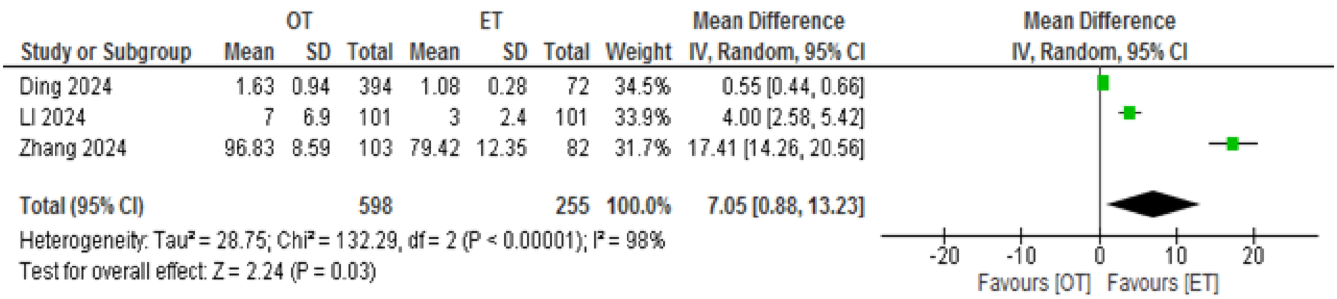

Fig 11: The forest plot for cosmetic satisfaction.

Discussion

Herein, we conducted a systematic review and meta-analysis to evaluate the surgical outcomes and safety of conventional open thyroidectomy (OT) versus endoscopic thyroidectomy (ET). Our analysis included seven studies 8_14 encompassing a total of 1230 patients, with 775 cases of OT and 455 cases of ET. Key parameters analyzed included operative time, complication rates, cosmetic outcomes, and patient safety. By consolidating the available evidence, we aim to provide clear guidance for surgeons and patients in selecting the most suitable surgical approach tailored to individual needs and preferences.

Outcomes

1. Blood Loss

Blood loss during surgery was evaluated in two studies.[11,12] included in this meta-analysis. A statistically significant reduction in blood loss was observed in the endoscopic thyroidectomy (ET) group compared to the open thyroidectomy (OT) group. The mean difference (MD) in blood loss between the groups was 1.29 ml, with a 95% confidence interval (CI) of [0.32, 2.25], yielding a p-value of 0.009, indicating statistical significance.

In more specific findings, Liu et al.[11] reported significantly lower intraoperative blood loss in the ET group compared to the OT group. In contrast, Xu et al.[12] found no significant difference in blood loss between the two procedures.

Moderate heterogeneity was noted among the pooled studies reporting this outcome, with an I^2 value of 66% and a Chi^2 p-value of <0.09, suggesting some variability in study results. Despite this heterogeneity, the findings support that ET is associated with lower intraoperative blood loss compared to OT.

Supporting these findings, Zhang et al.[13], in a meta-analysis of six trials involving 846 patients, reported a significant reduction in intraoperative blood loss with ET (MD = -32.02; 95% CI: -36.92 to -27.12; P < 0.00001).

2. Operative time

Operative time was evaluated in four studies.[10–12,14] A statistically significant shorter operative time was observed in the open thyroidectomy (OT) group compared to the endoscopic thyroidectomy (ET) group. The meta-analysis showed a mean difference (MD) in operative time of 37.6 minutes, with a 95% confidence interval (CI) of [42.77, 32.44], and a p-value of <0.00001, indicating strong statistical significance.

Major heterogeneity was noted among the pooled studies for this outcome, with an I^2 value of 82% and a Chi^2 p-value of <0.0008, suggesting substantial variability in the results. The forest plot for operative time further illustrates this variability.

The longer operative time for ET compared to OT can be attributed to several factors. First, ET involves more complex operative steps, starting from the visualization setup via the use of endoscopic camera to the port placement and then creation of the working space using endoscopic instruments. These instruments require more time for setup and maneuvering during surgery. Additionally, ET often requires more meticulous dissection and additional steps for tissue handling to avoid damage to surrounding structures, which further extends the time required. Finally, the learning curve associated with these minimally invasive techniques may contribute to longer operative times, particularly in the earlier stages of surgeon experience.

Supporting the current study, Gupta et al.[15], in a meta-analysis of 19 trials, found that the operative time for ET was significantly longer than for the OT approach.

Moreover, Wang et al.[16] in their meta-analysis found that the ET group had a significantly longer operative time compared to the OT group, with a WMD of 66.09 minutes (95% CI: 35.22–96.96; P < 0.0001).

3. Post-operative pain

Post-operative pain was evaluated in two studies.[11,12] The pooled mean difference (MD) showed no significant difference between open thyroidectomy (OT) and endoscopic thyroidectomy (ET). The MD was 0.21, with a 95% confidence interval (CI) of [0.77, 0.35], and a p-value of 0.47, indicating that the difference in pain levels between the two groups was not statistically significant.

The studies included in this analysis were homogeneous, as evidenced by a Chi^2 p-value of 0.98 and an I^2 value of 0%, suggesting minimal variability in the results.

In contrast, Oh et al.[17] in their meta-analysis reported that the ET group had significantly lower pain scores on postoperative day 1, with a weighted mean difference (WMD) of −1.41 (95% CI: −2.79, −0.03; P = 0.04) compared to the OT group. The differences in the results of the studies reflect how various factors, such as study design, timing of pain assessments, sample size, and postoperative care, can influence the findings in meta-analyses.

4. Hospital stay

Hospital stay was evaluated in four studies.[10–12,14] The pooled mean difference (MD) showed no significant difference between open thyroidectomy (OT) and endoscopic thyroidectomy (ET). The MD was 0.1 days, with a 95% confidence interval (CI) of [0.41, 0.2], and a p-value of 0.5, indicating that the length of hospital stay was similar between the two groups.

However, the pooled studies demonstrated major heterogeneity, with a Chi^2 p-value of <0.03 and an I^2 value of 68%, suggesting considerable variability in the results across the studies.

Complications

1. Post-operative hematoma

In this meta-analysis, post-operative hematoma was assessed by pooling data from two studies.[11,14] which revealed no significant difference between open thyroidectomy (OT) and endoscopic thyroidectomy (ET) in terms of the incidence of post-operative hematoma. The relative risk (RR) was 0.77 (95% CI: 0.15, 3.89) with a p-value of 0.75, indicating that the likelihood of developing a post-operative hematoma is similar between the two surgical approaches. Moreover, the homogeneity of the studies was supported by a Chi^2 p-value of 0.55 and an I^2 value of 0%, which suggests no substantial variability in the results across the studies.

The lack of significant differences in hematoma rates is supported by the existing literature. For instance, Oh et al.[17] found comparable hematoma incidences between ET and OT, reinforcing the notion that both surgical approaches are equally effective in preventing this complication. Similarly, Wang et al.[16] reported no significant differences between the two methods in terms of hematoma risk, although their results approached statistical significance. Likewise, Jasaitis et al.[9] and Gupta et al.[15] both observed no statistically significant differences in hematoma rates between ET and OT.

2. Vocal cord paralysis

Temporary vocal cord paralysis was evaluated in four studies.[10,13] The pooled relative risk (RR) analysis showed no significant difference between open thyroidectomy (OT) and endoscopic thyroidectomy (ET), with an RR of 0.94 (95% CI: 0.61, 1.47) and a p-value of 0.8. This indicates that the rate of temporary vocal cord paralysis is similar for both surgical approaches. The studies included in this analysis were homogeneous, as evidenced by a Chi^2 p-value of 0.62 and an I^2 value of 0%, indicating minimal variability in the results.

3. Cosmetic satisfaction

Cosmesis was evaluated in three studies[10,13,14], our meta-analysis showed that endoscopic thyroidectomy was superior to open thyroidectomy in cosmetic results. The pooled MD and 95%CI; 7.05[13.23, 0.88], p-value=0.03. individually each of our three studies was measured by different scale which was responsible for the major heterogeneity detected upon our meta-analysis ^{I2} 98% and chi-p 0.000001 random effect model was applied to overcome heterogeneity.

Supporting these findings, Zhang et al.[13] demonstrated in their meta-analysis that ET was associated with significantly better cosmetic satisfaction (OR = 38.92; 95% CI: [17.40, 87.06]; $p < 0.00001$) than OT. Similarly, Jiang et al.[18] in a systematic review and meta-analysis based on 5,664 cases from 20 publications, found that ET yielded higher cosmetic satisfaction compared to OT (WMD = 1.73; $p < 0.05$). These consistent findings across multiple studies reinforce the superior cosmetic outcomes associated with ET and highlight its value in achieving patient satisfaction and improved quality of life.

Conclusion

Our findings suggest that ET offers significant advantages in cosmetic outcomes and reduced intraoperative blood loss, making it an appealing choice for patients prioritizing aesthetic results. However, OT remains the gold-standard procedure due to its shorter operative time, simplicity, and widespread availability.

References

1. Boucai L, Zafereo M, Cabanillas ME: Thyroid cancer: A review. ***Jama***. 2024; 331(5): 425-435.
2.]Lin L, Chen S, Lu Y: Comparison between gas insufflation and gasless techniques for endoscopic transaxillary thyroidectomy. ***Front Endocrinol (Lausanne)***. 2024; 15: 1434419.
3. Fujii S, Ishibe A, Ota M, Yamagishi S, Watanabe J, Suwa Y, et al: Long-term results of a randomized study comparing open surgery and laparoscopic surgery in elderly colorectal cancer patients (Eld Lap study). ***Surg Endosc.*** 2021; 35:5686-5697.
4. Zhou D, Zhang Z, Dou X, Xia F, Li X: Advances in the assessment of cosmetic outcomes, sensory alteration in surgical areas, and health-related quality of life of endoscopic thyroidectomy. ***World J Surg Oncol.*** 2024; 22(1):52.
5. Zhang WC, Lu DN, Xu JJ, Guo HW, Ge MH, Zheng CM: Clinical application of endoscopic surgery using a gasless unilateral transaxillary approach in the treatment of primary hyperparathyroidism. ***Front Surg.*** 2022; 9: 962463.
6. Atiyeh BS, Rubeiz MT, Hayek SN: Aesthetic/ cosmetic surgery and ethical challenges. ***Aesthetic Plast Surg.*** 2008; 32(6): 829-39; discussion 840-1.
7. Lewandrowski KU, Telfeian AE, Hellinger S, León JFR, de Carvalho PST, Ramos MRF, et al: Difficulties, challenges, and the learning curve of avoiding complications in lumbar endoscopic spine surgery. ***Int J Spine Surg***. 2021; 15(suppl 3):521-537.
8. Cong R, Li X, Ouyang H, Xue W, Zhang Z, Xia F: Gasless, endoscopic trans-axillary thyroid surgery: Our series of the first 51 human cases. ***World J Surg Oncol.*** 2022; 20(1):9.
9. Jasaitis K, Maleckas A, Marcinkevičienė V, Daukšienė D, Krasauskas V, Aleksaitė A, et al: HRQOL after endoscopic transaxillary gasless hemithyroidectomy. ***Videosurgery Other Miniinvasive Tech.*** 2023; 18(2): 264-271.
10. Li SL, Du P, Lv T, Lu D, Shao C, Zhang Y, et al: Quantitative comparison of three thyroidectomy approaches in neck muscles, voice, and swallowing functions. ***Asian J Surg.*** 2024; 47(4): 1734-1739.
11. Liu Y, Wang J, Chen S, Lv H, Yu S, Ran X, et al: Preliminary report on a novel technique for endoscopic transaxillary thyroidectomy: A case–control study. ***Int J Surg.*** 2024; 110(2): 654-659.
12. Xu T, Qin X, Zhang Y, Li P, Ran Y, Fan Y, et al: A prospective study comparing the gasless endoscopic thyroidectomy trans-axillary approach to conventional open thyroidectomy. Health and quality of life outcomes. ***Surg Endosc*** 2024; 38(4): 1995-2009.
13. Zhang Y, Zhao Y, Tang H, Zou H, Li Y, Bian X: Patient satisfaction and operator proficiency in gasless transaxillary endoscopic thyroidectomy under IONM. A retrospective cohort study. ***Front Endocrinol (Lausanne).*** 2024; 15: 1457571.

14. Ding Y, Qiu C, Zhu C, Li Y, Geng X, Lv G, et al: Comparison of gasless transaxillary endoscopic thyroidectomy, endoscopic thyroidectomy via areola approach and conventional open thyroidectomy in patients with unilateral papillary thyroid carcinoma. ***World J Surg Oncol.*** 2024; 22(1): 148.

15. Gupta K, Kataria K: Comparison of different approaches of endoscopic thyroidectomy and open thyroidectomy: A meta-analysis. ***Indian J Surg.*** 2024 Jan 3:1-4.

16. Wang Y, Zhou S, Liu X, Rui S, Li Z, Zhu J, Wei T: Transoral endoscopic thyroidectomy vestibular approach vs conventional open thyroidectomy. Meta-analysis. ***Head Neck***. 2021; 43(1): 345-353.

17. Oh MY, Chai YJ, Yu HW, Kim SJ, Choi JY, Lee KE: Transoral endoscopic thyroidectomy vestibular approach as a safe and feasible alternative to open thyroidectomy: a systematic review and meta-analysis. ***Int J Surg***. 2023 1; 109(8): 2467-2477.

18. Jiang WJ, Yan PJ, Zhao CL, Si MB, Tian W, Zhang YJ, Tian HW, Feng SW, Han CW, Yang J, Yang KH: Comparison of total endoscopic thyroidectomy with conventional open thyroidectomy for treatment of papillary thyroid cancer: a systematic review and meta-analysis. ***Surg Endosc.*** 2020; 34: 1891-1903.