

## Comparative Evaluation of Energy-Based Modern Thyroidectomy Versus Conventional Thyroidectomy: Perioperative Outcomes, Complications, and Six-Month Patient-Reported Outcomes

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### ABSTRACT

**Background** :Thyroid surgery (thyroidectomy) is one of the most common endocrine surgeries worldwide. Endoscopic procedures for thyroid surgery have been available since 1998, but their diffusion has remained limited because their advantages have never been demonstrated. Hitherto, owing to recent technological advances, postmodern thyroid surgery techniques have been developed, including those based on advanced energy-based vessel-sealing systems, which can enhance surgical efficiency and outcomes. **Objective:** The aim of this study was to compare the perioperative outcomes, postoperative complications, and long-term patient-reported outcomes of the conventional and modern thyroidectomy techniques. **Methods:** A retrospective study of 240 patients who underwent thyroid surgery from June 2025 to April 2026, divided into conventional and modern thyroidectomy groups, analyzed demographic data, operative details, complications, and 6-month outcomes. Participants chose minimally invasive video-assisted thyroidectomy (MIVAT) or conventional thyroidectomy (CT). Exclusion criteria included nodules >35 mm, thyroiditis, or thyroid volume >20 mL. Assessed outcomes included preoperative diagnosis, operative time, postoperative pain, complications, and cosmetic results. Primary endpoints were postoperative hypocalcemia and recurrent laryngeal nerve injury. Secondary outcomes included operative time, blood loss, pain, hospital stay, voice scores, scar satisfaction, quality of life, return-to-work time, and TSOS. **Results:** The modern thyroidectomy group showed a significantly shorter operative duration ( $82.2 \pm 18.4$  vs.  $119.9 \pm 24.6$  minutes;  $p < 0.001$ ), lower intraoperative blood loss ( $70.8 \pm 29.5$  vs.  $148.2 \pm 48.1$  mL;  $p < 0.001$ ), lower postoperative pain scores ( $3.82 \pm 1.31$  vs.  $6.25 \pm 1.54$ ;  $p < 0.001$ ), and a shorter length of hospital stay ( $1.94 \pm 0.73$  vs.  $3.39 \pm 1.08$  days;  $p < 0.001$ ). Postoperative hypocalcemia occurred significantly less frequently in the modern group (9.2% vs. 20.8%; OR = 0.38; 95% CI: 0.18–0.82;  $p = 0.018$ ). There was no statistically significant difference between the groups in terms of injury of the recurrent laryngeal nerve. At 6 months post-surgery, the modern group had significantly improved voice function, scar satisfaction, health-related quality of life, time to return to work, and TSOS scores (all  $p < 0.001$ ). **Conclusion:** Modern thyroidectomy techniques were found to have better perioperative outcomes, less postoperative hypocalcemia, and better long-term patient-reported outcomes than conventional thyroidectomy. These results validate the use of modern energy-based surgical techniques in thyroid surgery to improve surgical outcomes.

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## 1. Introduction

Thyroid surgery, particularly thyroidectomy, is a very common endocrine surgery performed throughout the world and is the treatment of choice for many thyroid conditions, both benign and malignant. The first endoscopic procedures for the removal of small thyroid nodules were introduced in 1998 [1]. Still, they have not become very popular because the advantages of this minimally invasive surgery seem very limited, particularly when compared to a well-standardized operation such as thyroidectomy, which has reached an excellent standard in recent years. Given our positive experience with this video-assisted procedure, the researcher sought further validation through a prospective study comparing 2 groups of patients undergoing thyroid surgery in our department. The study aimed to demonstrate the potential advantages of this technique compared with conventional surgery, as well as its drawbacks, particularly regarding costs and operative time. The most frequent indications are multinodular goiters, symptomatic thyroid enlargements, Graves' disease, and differentiated thyroid medical treatments. Although thyroid surgery has improved significantly over time, it can still have complications that may affect postoperative recovery and patients' quality of life.

Postoperative hypocalcemia from parathyroid damage or hypoperfusion and recurrent laryngeal nerve injury with subsequent voice changes (temporary or permanent) are the most important complications [2]. In addition, operating time, blood loss during surgery, postoperative pain, and length of hospital stay are important factors affecting patients' clinical outcomes and satisfaction after surgery.

Over the past two decades, thyroid surgery has undergone drastic changes due to the introduction of new energy-based surgical instruments. In particular, ultrasound-based and bipolar vessel-sealing systems enable simultaneous tissue dissection and hemostasis, potentially reducing the need for traditional ligatures and improving surgical efficiency. Many studies have demonstrated that these technologies may be associated with reduced operative time, lower blood loss, and quicker postoperative recovery [3].

In addition to traditional clinical endpoints, patient-reported outcomes are increasingly gaining importance. Aspects such as voice function, cosmetic satisfaction with the scar, health-related quality of life, and the speed of social and professional reintegration are now

considered essential components of a comprehensive assessment of surgical outcomes. Nevertheless, many previous studies have focused primarily on perioperative parameters and postoperative complications, while long-term patient-centered outcomes have been comparatively rarely analyzed [4].

Furthermore, limited data from Iraq and other Middle Eastern countries are available that directly compare conventional and modern thyroidectomy techniques, considering both clinical and patient-reported outcomes. Therefore, there is an ongoing need for studies investigating the potential benefits of modern energy-based technologies across different clinical settings [5].

The present study aimed to compare perioperative outcomes, postoperative complications, and long-term patient-reported outcomes between conventional and modern thyroidectomy. Special attention was paid to the incidence of postoperative hypocalcemia and recurrent laryngeal nerve injuries, as well as functional, cosmetic, and quality of life-related outcomes six months after surgery.

### 1. Novelty of the Study

Although numerous studies have investigated the efficacy of modern energy-based devices in thyroid surgery, most have focused primarily on perioperative parameters and postoperative complications. Data on the impact of these technologies on long-term patient-reported outcomes remain limited, particularly in healthcare systems of developing and emerging countries [6].

The current study is distinguished by a comprehensive evaluation of both clinical and patient-centered endpoints after conventional and modern thyroidectomy. Additionally, several prior studies were included, including Thyroid surgery trends and outcomes in Iraq: A retrospective review by Alwani (2025) [7] Comparative Analysis of Conventional and Novel Approaches to Thyroidectomy by Kdhuair, Abdulkareem and Khalaf (2024), [8] and The frequency of hypercalcemia among patients who underwent total thyroidectomy: A prospective cohort study by Hassan Melek (2026). [9]

In addition to analyzing operative metrics and complication rates, long-term functional and quality-of-life outcomes are examined, including vocal function, satisfaction with cosmetic scarring, time to return to work, and the Thyroid Surgery Outcome Score (TSOS), as this

pattern allows for a more comprehensive assessment of surgical success from the patient's perspective[10].

Conversely, this study is one of the few comparative studies in Iraq to evaluate the effects of modern energy-based technologies on short- and long-term treatment outcomes following thyroidectomy. The study provides regional evidence and advances understanding of the clinical benefit of modern thyroidectomy techniques in contemporary endocrine surgery by combining objective surgical parameters with subjective patient-reported outcomes.

## **2. Materials and Methods**

### **3.1: Study Design and Setting**

This study was a retrospective comparative cohort study to assess and compare perioperative outcomes, postoperative complications, and patient-reported outcomes of conventional thyroidectomy with modern thyroidectomy.

The study was conducted at Al-Nasiriyah Teaching Hospital and affiliated private hospitals in The Qar Governorate, Republic of Iraq, during June 2025 and April 2026, 120 consecutive consenting patients undergoing surgery for either a thyroid nodular disease or a “low risk “papillary carcinoma were selected based on the following inclusion criteria: thyroid nodule not exceeding 35 mm of maximum diameter, absence of both echo graphic and biochemical signs of thyroiditis, and thyroid volume not exceeding 20 mL. They were then randomly allotted to 1 of these surgical procedures: (1) minimally invasive video-assisted thyroidectomy (MIVAT) or (2) conventional thyroidectomy (CT).

We retrospectively reviewed the medical records of patients who underwent thyroidectomy between June 22, 2025, and April 22, 2026. This study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement, a guideline for reporting observational studies[11].

### **3.2: Ethical Considerations**

This study was approved by the Al-Nasiriyah Teaching Hospital Ethics Review Committee (Approval No.: 266). As this was a retrospective study using anonymized existing medical records, written informed consent was waived. All study procedures were performed in

accordance with the ethical principles of the Declaration of Helsinki [12].

**3.3: Study Population**

A total of 240 patients who underwent thyroidectomy during the study period were included. The patients came from a diverse group of ethnic backgrounds, including Arab, Asian, and Kurdish, present in Iraq. Patients were divided into two groups based on the surgical technique used:

- **Conventional Thyroidectomy Group: 120 cases**
- **Modern Thyroidectomy Group: 120 cases**

The mean age of all participants was  $43.5 \pm 14.7$  years. The average age in the conventional group was  $45.4 \pm 13.9$  years, and in the modern group, it was  $41.5 \pm 15.3$  years.

**3.4: Selection Criteria**

Patients meeting the following criteria were included, as illustrated in Table 1:

No.	Inclusion Criterion
1	Age 18 years or older
2	Patients who underwent thyroidectomy during the study period
3	Patients with possession of complete perioperative and postoperative data, collected as per genuine recorded data
4	Patients who completed a 6-month postoperative follow-up with the hospital

**Table1 -Selection Criteria**

**Exclusion Criteria**

Patients meeting any of the following criteria were excluded:

Exclusion Criterion	
o.	
	Patients whose medical records were not up to date
	Patients who had undergone surgery elsewhere or for any other reason
	Patients who underwent concurrent other major cervical surgery
	Patients who were unable to follow up during the post-surgical period

**Table 2-Exclusion Criteria**

*The process of patient selection and allocation to the study groups is illustrated in Figure 1.*

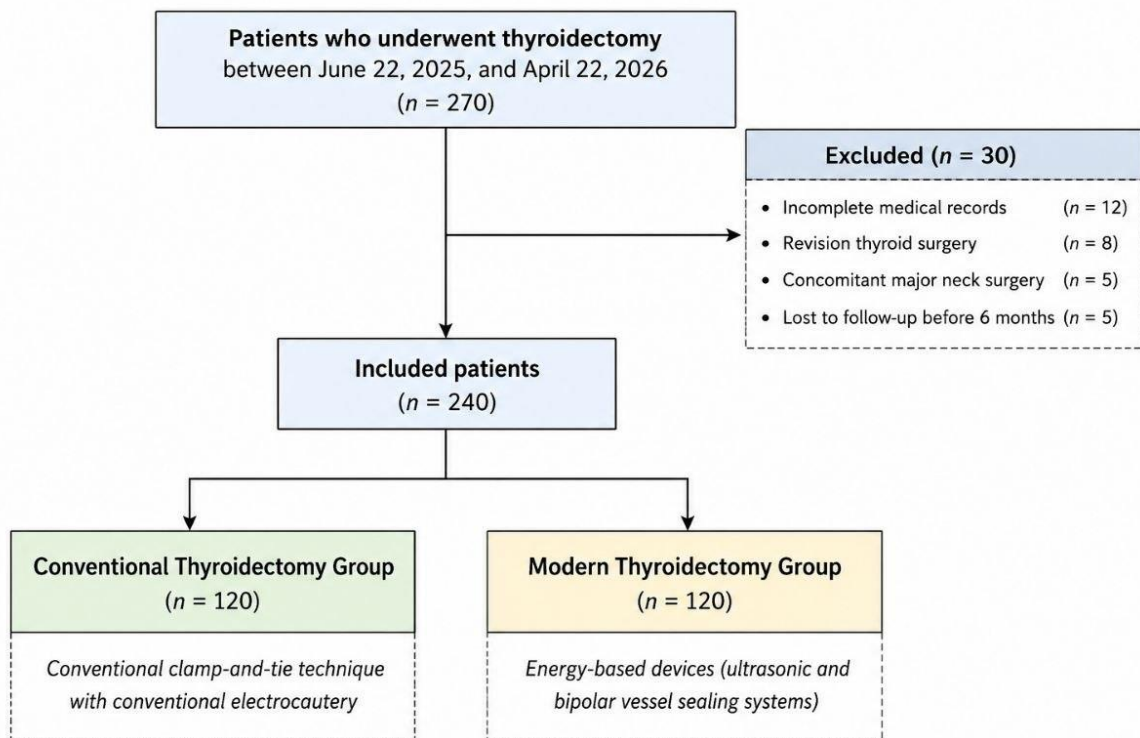
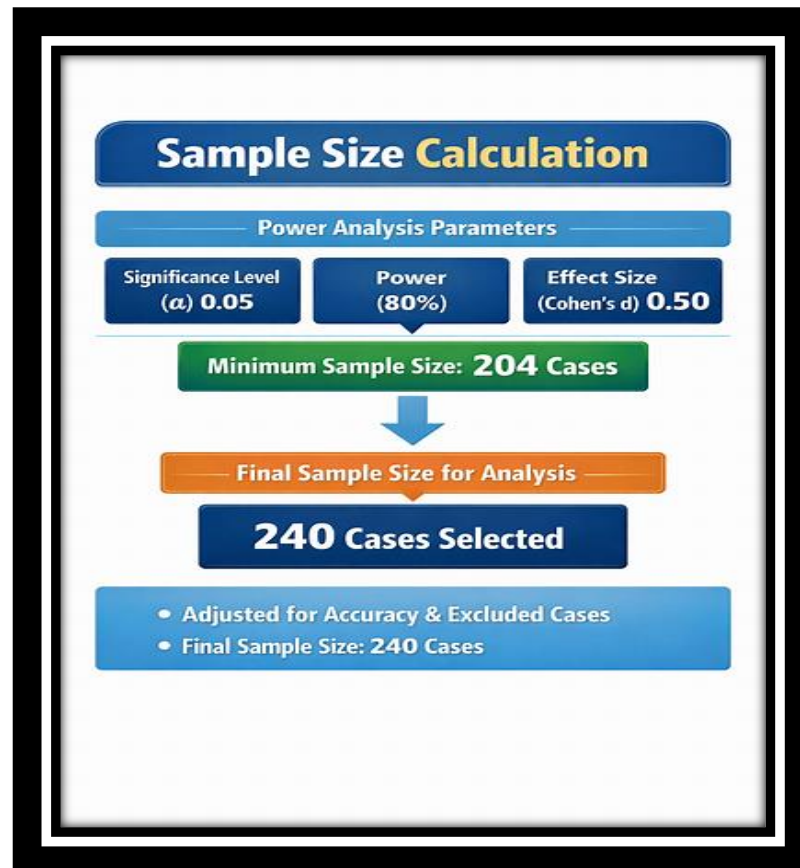


Figure 1. Flow diagram of patient selection and study enrollment.

### 3.5: Sample Size Calculation

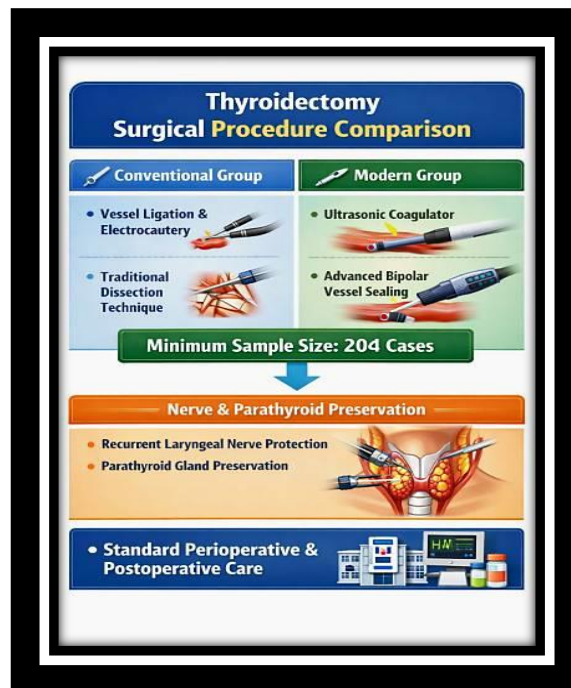
The sample size was calculated using G\*Power version 3.1 (Heinrich-Heine University, Düsseldorf, Germany) [13]. Assuming a significance level ( $\alpha$ ) of 0.05, a power of 80%, and a medium effect size (Cohen’s  $d = 0.50$ ) [14], the minimum required sample size was calculated to be 204 cases. To improve statistical accuracy and account for excluded cases, a final sample size of 240 cases was used for analysis. This information is depicted in Figure 2.



**Figure 2- Sample Size Calculation**

### 3.6: Surgical Procedure

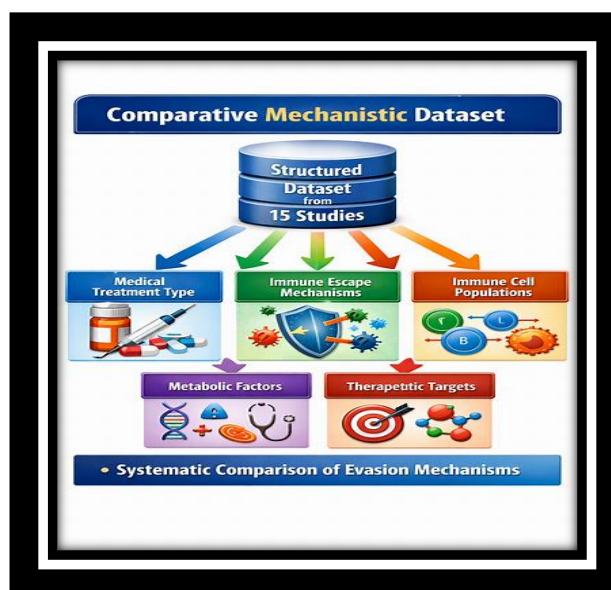
All surgeries were done by experienced endocrine surgeons under general anesthesia. Conventional group vessels were ligated, and tissues were dissected in the traditional manner using electrocautery [15]. In the modern group, energy devices such as an ultrasonic coagulator and an advanced bipolar vessel-sealing system were used to achieve simultaneous tissue incision and hemostasis [16]. In both groups, careful identification and preservation of the recurrent laryngeal nerve and parathyroid glands were ensured. Perioperative and postoperative management was performed in accordance with standard procedures, as this information is depicted in Figure 3.



**Figure 3-Surgical Procedure**

### 2.7 Data Set construction

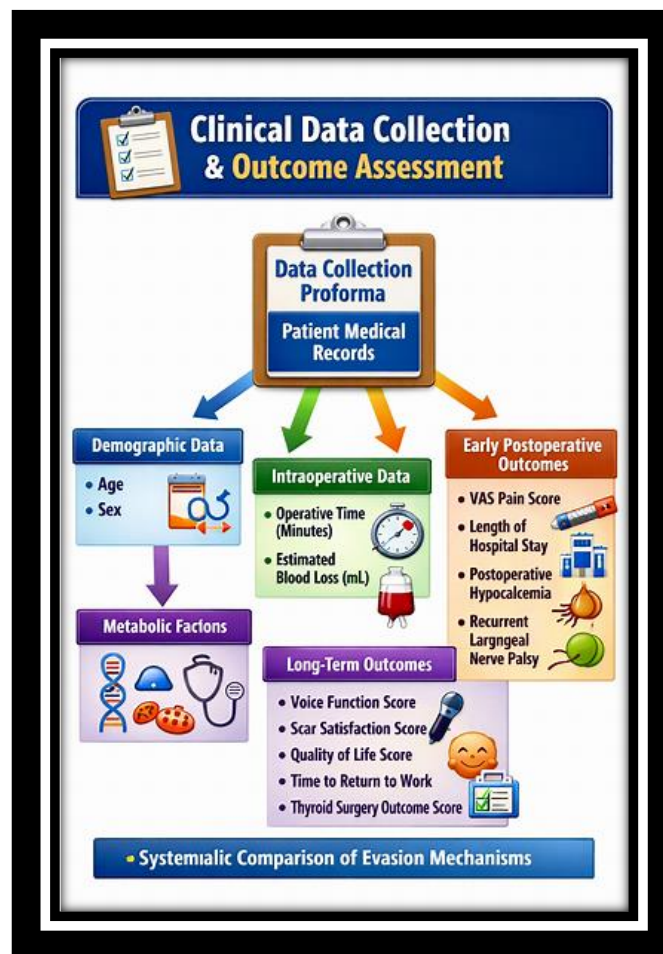
A structured dataset was constructed from the 15 eligible studies to facilitate comparative mechanistic analysis. Extracted variables included medical treatment type, immune escape mechanisms, immune cell populations involved, metabolic factors, and proposed therapeutic targets. This dataset enabled systematic comparison of biological mechanisms contributing to evasion. Figure 4 illustrates this information in a diagram.



**Figure 4- Data Set construction**

**2.8 Data Collection**

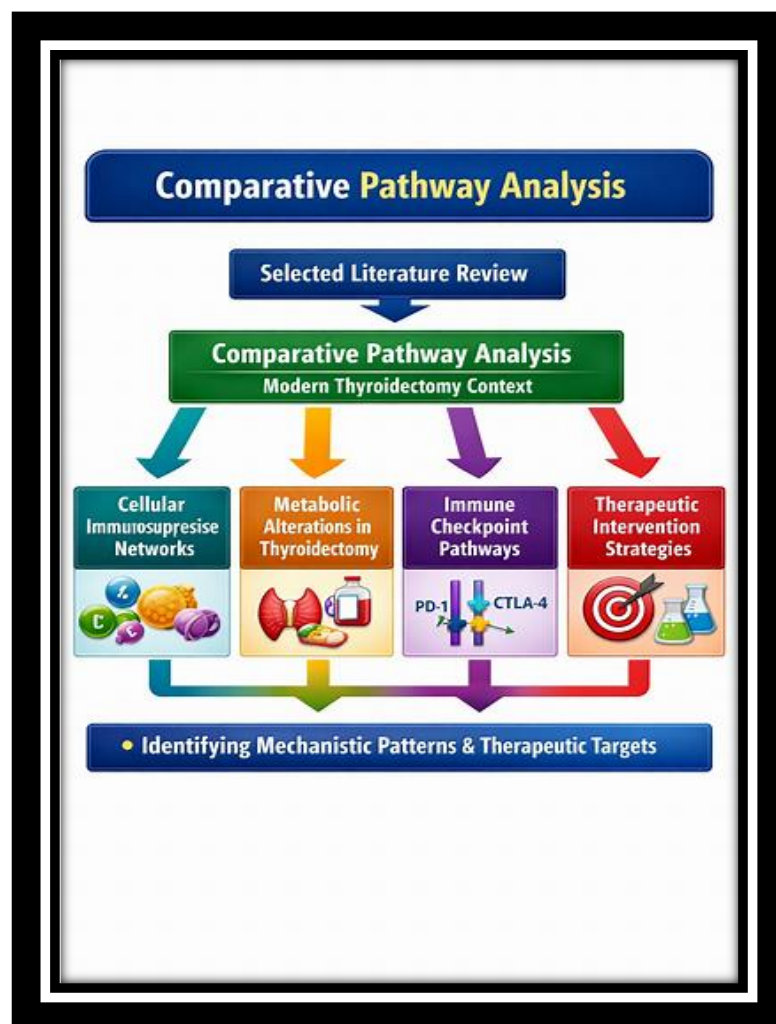
Data were collected on a pre-designed data collection proforma from the patients' medical records. Demographic data collected were age and sex. Operative time (in minutes) and estimated blood loss (in milliliters) were the intraoperative data. Early postoperative outcomes were measured 24 hours after surgery using the Visual Analog Scale (VAS), [17]. length of hospital stay, postoperative hypocalcemia, and recurrent laryngeal nerve palsy. Long-term postoperative outcomes were measured at 6 months post-surgery. They included Voice function score, Scar satisfaction score, Quality of life score, Time to Return to work, and the Thyroid Surgery Outcome Score (TSOS).



**Figure 5-Data Collection**

## 2.9 Mechanistic Comparative Analysis

To strengthen the study's analytical framework, the selected literature was further examined through comparative pathway analysis. Mechanisms identified in the included studies were categorized into four principal biological domains: cellular immunosuppressive networks, metabolic alterations within the Modern Thyroidectomy, immune checkpoint signaling pathways, and emerging therapeutic intervention strategies. This analytical categorization enabled the identification of recurrent mechanistic patterns across multiple medical treatment types and the mapping of potential therapeutic targets within Modern Thyroidectomy. This mechanistic comparative analysis is displayed in figure 6 below:



**Figure 6- Mechanistic Comparative Analysis**

### 3.8 Outcome Measures

The main results of the study were the rate of postoperative hypocalcemia and recurrent laryngeal nerve injury. Secondary outcomes were operative time, estimated blood loss during surgery, hospital days, voice function, cosmetic satisfaction, quality of life, return to work, and Thyroid Surgery Outcome Score (TSOS).

**3.9 All follow-up was conducted in accordance with the clinical post-surgery protocol; satisfaction was evaluated at 6 follow-up visits at the time of hospital stay and at all follow-up visits.** Follow-up was conducted during the post-surgery recovery period, and patient satisfaction and quality of life were assessed six months after surgery.

### 3.10: Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA) [18]. Continuous variables were expressed as mean  $\pm$  standard deviation (SD), and categorical variables were presented as frequencies and percentages. The normality of continuous variables was assessed using the Shapiro–Wilk test [19]. For normally distributed variables, an independent-samples t-test was used; for non-normally distributed variables, the Mann–Whitney U test was used. Pearson's chi-square test or Fisher's exact test was used to compare categorical variables [20]. Odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated for the categorical outcome. All tests were two-sided, and a p-value  $< 0.05$  was considered statistically significant.

## 3. Results

### 4.1 Study Subjects

A total of 270 patients who underwent thyroidectomy during the study period were initially evaluated. After applying the selection and exclusion criteria, 240 patients were finally enrolled for analysis. Of these, 120 patients were classified into the conventional thyroidectomy group and 120 patients into the modern thyroidectomy group. The process of patient selection and group classification is shown in Figure 1.

### 4.2 Patient Background Factors

The background factors of the study patients are shown *in Table 1*. The mean age of all subjects was  $43.5 \pm 14.7$  years. The mean age in the conventional group was  $45.4 \pm 13.9$  years, which was significantly higher than that in the modern group ( $41.5 \pm 15.3$  years) (p

= 0.040). There was no significant difference in gender distribution between the two groups.

Variable	Conventional Thyroidectomy (n = 120)	Modern Thyroidectomy (n = 120)	p-value
Age (years), mean ± SD	45.4 ± 13.9	41.5 ± 15.3	0.040
Male, n (%)	42(35.0)	46 (38.3)	0.593
Female, n (%)	78 (65.0)	74 (61.7)	0.593

**Table 3. Baseline demographic characteristics of the study population.**

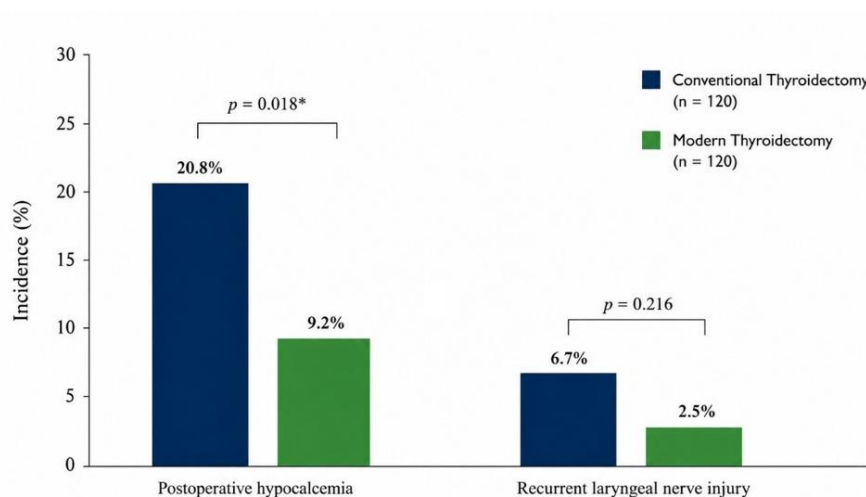
#### 4.3 Primary outcomes

The results for the primary outcomes of postoperative hypocalcemia and recurrent laryngeal nerve injury are shown in Table 2. Postoperative hypocalcemia was observed in 25 cases (20.8%) in the conventional group and 11 cases (9.2%) in the modern group. The incidence was significantly lower in the modern group (OR = 0.38, 95% CI: 0.18–0.82,  $p = 0.018$ ). Consequently, recurrent laryngeal nerve injury was observed in 8 cases (6.7%) in the conventional group and 3 cases (2.5%) in the modern group. Although the incidence was lower in the modern group, it did not reach statistical significance (OR = 0.36, 95% CI: 0.09–1.39,  $p = 0.216$ ). The comparison of primary outcomes between the two groups is presented in Table 2 and Fig. 2

Outcome	Conventional Thyroidectomy (n = 120)	Modern Thyroidectomy (n = 120)	Odds Ratio (95% CI)	p-value
Postoperative hypocalcemia, n (%)	25 (20.8)	11 (9.2)	0.38 (0.18–0.82)	0.018
Recurrent laryngeal nerve injury, n (%)	8 (6.7)	3 (2.5)	0.36 (0.09–1.39)	0.216

**Table 4. Comparison of Primary Outcomes Between the Conventional and Modern Thyroidectomy Groups**

Abbreviations: CI, confidence interval; OR, odds ratio.



**Figure 7** Comparison of primary outcomes between the conventional and modern thyroidectomy groups.

\* Statistically significant ( $p < 0.05$ ).

#### 4.4 Secondary outcomes

The comparison results for the secondary endpoints are shown in Table 3. The operative time was significantly shorter in the modern group ( $82.2 \pm 18.4$  minutes) than in the conventional group ( $119.9 \pm 24.6$  minutes;  $p < 0.001$ ). The intraoperative blood loss was also significantly lower in the modern group, at  $70.8 \pm 29.5$  mL, compared with  $148.2 \pm 48.1$  mL in the conventional group ( $p < 0.001$ ).

The postoperative 24-hour pain score was significantly lower in the modern group ( $3.82 \pm 1.31$  vs.  $6.25 \pm 1.54$ ,  $p < 0.001$ ), and the length of hospital stay was also significantly shorter in the modern group ( $1.94 \pm 0.73$  days vs.  $3.39 \pm 1.08$  days,  $p < 0.001$ ). At the 6-month postoperative assessment, the modern group showed significantly higher scores than the conventional group in all aspects: voice function score, scar satisfaction score, and quality of life score (all  $p < 0.001$ ).

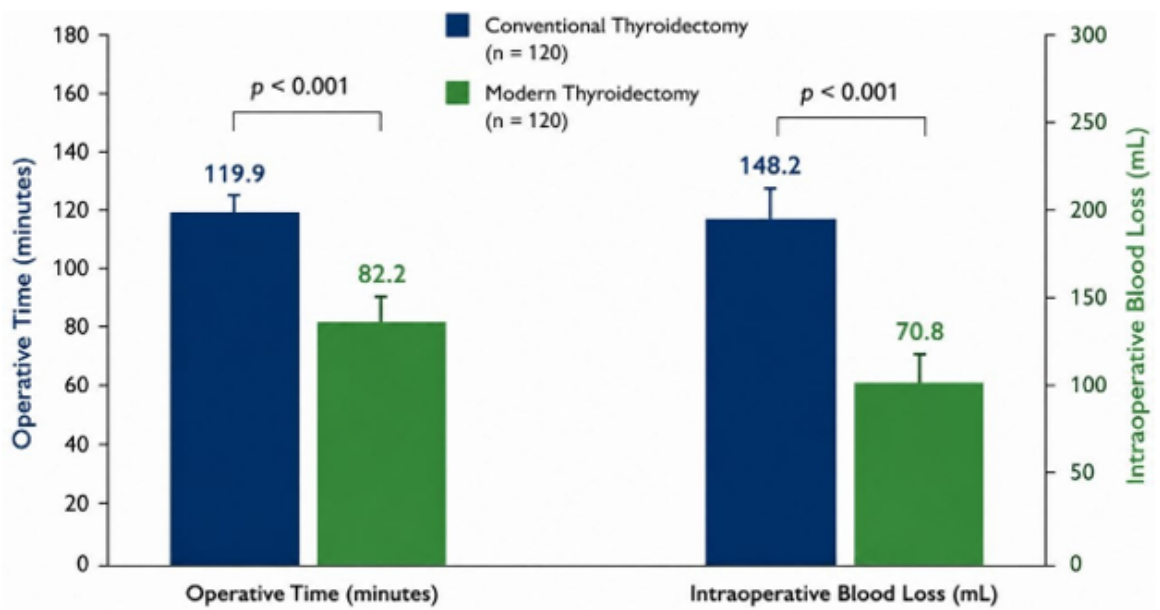
Furthermore, the time to return to work was significantly shorter in the modern group, and the Thyroid Surgery Outcome Score (TSOS) was significantly higher (Table 3). Overall, modern thyroidectomy was shown to improve perioperative outcomes and patient-reported outcomes compared to the conventional method, and to reduce the incidence of postoperative hypocalcemia significantly. This information is presented in Table 5

Outcome	Conventional Thyroidectomy (n = 120)	Modern Thyroidectomy (n = 120)	p-value
Operative time (min), mean $\pm$ SD	$119.9 \pm 24.6$	$82.2 \pm 18.4$	<0.001
Intraoperative blood loss (mL), mean $\pm$ SD	$148.2 \pm 48.1$	$70.8 \pm 29.5$	<0.001
Postoperative pain score (VAS), mean $\pm$ SD	$6.25 \pm 1.54$	$3.82 \pm 1.31$	<0.001
Length of hospital stay (days), mean $\pm$ SD	$3.39 \pm 1.08$	$1.94 \pm 0.73$	<0.001

<b>Voice function score, mean ± SD</b>	76.3 ± 11.2	89.6 ± 8.4	<0.001
<b>Scar satisfaction score, mean ± SD</b>	69.4 ± 10.8	88.7 ± 7.9	<0.001
<b>Quality of life score, mean ± SD</b>	74.9 ± 10.6	89.4 ± 7.5	<0.001
<b>Return-to-work time (days), mean ± SD</b>	23.5 ± 7.1	13.1 ± 4.6	<0.001
<b>Thyroid Surgery Outcome Score (TSOS), mean ± SD</b>	68.8 ± 11.4	86.2 ± 8.1	<0.001

**Table 5. Comparison of Secondary Outcomes Between the Conventional and Modern Thyroidectomy Groups**

*Abbreviations: SD, standard deviation; VAS, Visual Analog Scale; TSOS, Thyroid Surgery Outcome Score.*



**Figure 8.** Comparison of operative time and intraoperative blood loss between the conventional and modern thyroidectomy groups.

Values are presented as mean ± SD. *p*-values were calculated using the independent *t*-test.

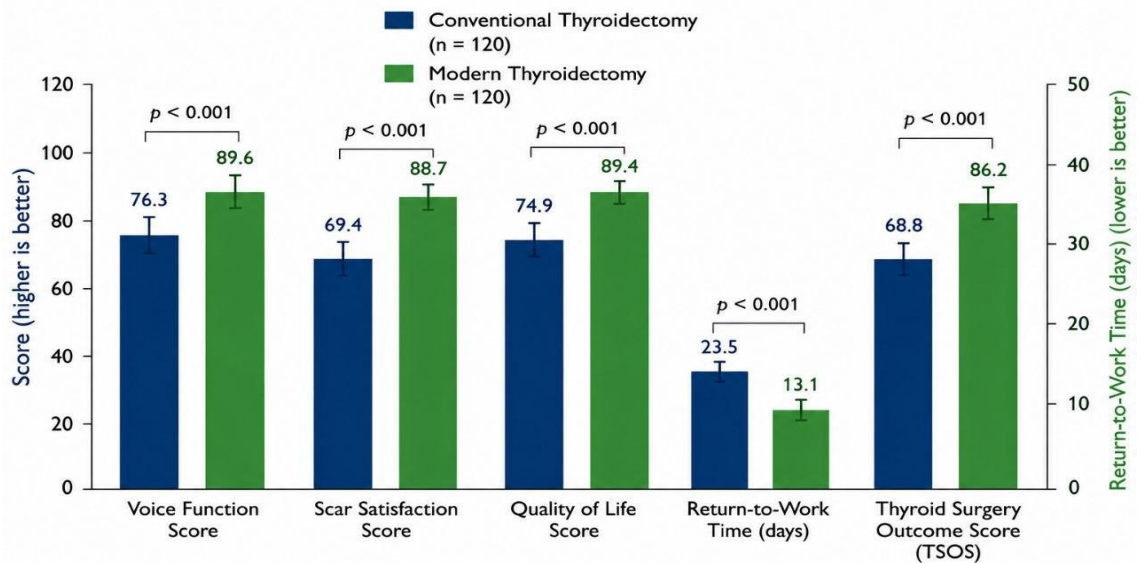
#### 4.5 Long-term Outcomes

Table 4 compares long-term outcomes at 6 months postoperatively. The modern thyroidectomy group showed significantly higher scores for voice function, scar satisfaction, Quality of Life (QOL), and Thyroid Surgery Outcome Score (TSOS) compared to the conventional method group (all  $p < 0.001$ ). Furthermore, the time to return to work was significantly shorter in the modern thyroidectomy group ( $p < 0.001$ ).

Outcome	Conventional Thyroidectomy (n = 120)	Modern Thyroidectomy (n = 120)	p-value
Voice Function Score, mean $\pm$ SD	76.3 $\pm$ 11.2	89.6 $\pm$ 8.4	<0.001
Scar Satisfaction Score, mean $\pm$ SD	69.4 $\pm$ 10.8	88.7 $\pm$ 7.9	<0.001
Quality of Life Score, mean $\pm$ SD	74.9 $\pm$ 10.6	89.4 $\pm$ 7.5	<0.001
Return-to-Work Time (days), mean $\pm$ SD	23.5 $\pm$ 7.1	13.1 $\pm$ 4.6	<0.001
Thyroid Surgery Outcome Score (TSOS), mean $\pm$ SD	68.8 $\pm$ 11.4	86.2 $\pm$ 8.1	<0.001

**Table 6. Comparison of Long-Term Patient-Reported Outcomes Between the Conventional and Modern Thyroidectomy Groups at 6 Months Postoperatively**

*Abbreviations: SD, standard deviation; TSOS, Thyroid Surgery Outcome Score.*



**Figure 4.** Comparison of long-term patient-reported outcomes between the conventional and modern thyroidectomy groups at 6 months postoperatively. Values are presented as mean  $\pm$  SD. *p*-values were calculated using the independent *t*-test. TSOS, Thyroid Surgery Outcome Score.

Figure 9. Comparison of voice function score, scar satisfaction score, QOL score, time to return to work, and TSOS at 6 months postoperatively between the conventional thyroidectomy group and the modern thyroidectomy group.

### 5. Discussion

This study compared the perioperative outcomes, postoperative complications, and patient-reported outcomes of conventional thyroidectomy and modern thyroidectomy. The results showed that modern thyroidectomy was significantly associated with shorter operation times, reduced intraoperative blood loss, decreased postoperative pain, shorter hospital stays, improved long-term functional outcomes and cosmetic satisfaction, and a lower incidence of postoperative hypocalcemia. Consequently, although the incidence of recurrent laryngeal nerve injury was lower in the modern surgery group, the difference did not reach statistical significance. The findings suggest that energy-based thyroidectomy may improve perioperative and patient-reported outcomes; however, prospective studies are needed, as these findings are generally consistent with previous studies supporting the efficacy of thyroid surgery using energy devices reported in recent years [21].

Postoperative hypocalcemia is one of the most frequent complications after thyroidectomy, primarily caused by damage to or impaired blood flow to the parathyroid glands [22]. In this study, the incidence of postoperative hypocalcemia was significantly lower in the

modern thyroidectomy group. This result is consistent with the findings of meta-analyses by Docimo *et al.* (1) and Melck *et al.* (3) [23,24]. These studies reported that the use of ultrasonic dissectors and bipolar energy devices minimizes tissue damage and heat diffusion, thereby facilitating preservation of parathyroid blood flow and reducing the incidence of hypocalcemia; similar mechanisms may have been involved in this study.

Regarding recurrent laryngeal nerve injury, although the incidence was lower in the modern thyroidectomy group, no significant difference was observed. This finding is consistent with previous studies, and many randomized controlled trials and meta-analyses have not shown that the use of energy devices significantly reduces the rate of recurrent laryngeal nerve injury[25]. It is believed that surgeon experience and nerve identification techniques are more important for preserving the recurrent laryngeal nerve than the equipment used. Furthermore, the usefulness of intraoperative nerve monitoring has been reported in recent years, showing that combining nerve monitoring with energy devices is more important for preventing nerve injury than using energy devices alone[26].

Regarding perioperative outcomes, this study showed a significant reduction in operative time and intraoperative blood loss in the modern thyroidectomy group. This is consistent with the results of previous studies and is thought to be due to the ability of energy devices to simultaneously manage blood vessels and achieve hemostasis, thus shortening the time required for ligation and instrument exchange[27]. Furthermore, improved visibility of the surgical field due to effective hemostasis is considered to have contributed to reduced operation time, enabling safe and efficient surgical manipulation. In addition, this study showed significantly lower postoperative pain scores and shorter hospital stays in the modern thyroidectomy group. These results are also consistent with previous reports, suggesting that reduced tissue damage and suppression of inflammatory responses due to excellent hemostasis may have promoted faster postoperative recovery (1,6). Accelerated postoperative recovery may not only improve patient satisfaction but also contribute to the efficient use of medical resources and reduction of medical costs. A significant finding of this study is that the long-term outcomes at 6 months postoperatively were significantly better in the modern thyroidectomy group. Voice Function scores, scar satisfaction scores, QOL scores, and TSOS were all significantly

higher in the modern surgery group. In recent years, interest in patient-reported outcomes after thyroid surgery has increased, and it has been reported that the effects of scars and preservation of voice function significantly affect patient satisfaction and QOL [28].

## 6. Conclusion

This study compared the clinical outcomes of conventional thyroidectomy and modern thyroidectomy. The results showed that modern thyroidectomy, compared with the conventional method, significantly reduced operative time, intraoperative blood loss (Table 5), postoperative pain scores, and hospital stay, thereby promoting perioperative recovery (Table 7).

Regarding the primary endpoints, the incidence of postoperative hypocalcemia was significantly lower in the modern thyroidectomy group, demonstrating its effectiveness in reducing postoperative complications (Table 4, Figure 2). On the other hand, although a trend towards a lower incidence of recurrent laryngeal nerve injury was observed in the modern surgery group, no statistically significant difference was found (Table 4, Figure 2). Furthermore, long-term outcome assessments at 6 months postoperatively showed significantly higher scores for vocal function, scar satisfaction, QOL, and Thyroid Surgery Outcome Score (TSOS) in the modern thyroidectomy group. The period until return to work was also significantly shortened (Table 4, Figure 4). These results suggest that modern thyroidectomy contributes to improved functional and cos, as well as patient satisfaction.

In summary, Modern thyroidectomy was associated with improved perioperative and patient-reported outcomes in this cohort, suggesting it to be a safe and effective surgical technique.

## 4. Study Limitations

Despite the comprehensive analysis presented in this study, several limitations should be acknowledged. First, the Modern Thyroidectomy is a highly dynamic and heterogeneous biological system that varies significantly across medical treatment types and even among patients with the same symptoms [29]. This heterogeneity limits the generalizability of mechanistic conclusions across different malignancies. Second, although the analysis incorporated a broad range of experimental and clinical studies,

differences in study design, methodology, and sample size may introduce variability in reported findings. Additionally, many mechanisms of immune escape have been investigated primarily in preclinical models, which may not fully capture the complexity of the human Immune system. Third, the rapidly evolving field of medical treatment and immunotherapy means that new therapeutic targets and immune regulatory pathways continue to emerge [30]. Consequently, some mechanisms described in the current study may be further refined or expanded by future research.

These limitations highlight the need for more integrative and multidisciplinary approaches that combine experimental biology, computational modeling, and clinical research to better understand immune escape mechanisms in medical treatment.

## 6. Future Directions

- Future research should focus on integrating multi-omics technologies to characterize better the spatial and functional complexity of the Modern Thyroidectomy. Approaches such as strong association exists between surgeon volume and patient outcomes; surgeons' awareness of their own outcomes is critical, and immune populations.
- In addition, the development of predictive biomarkers to identify patients most likely to benefit from immunotherapy remains a major priority. Composite biomarkers that integrate mutational burden, immune cell infiltration patterns, and metabolic features of Modern Thyroidectomy may significantly improve patient satisfaction.
- The incidence of thyroid medical treatment is increasing across the United States; this includes thyroid medical treatments of all symptom sizes and stages.
- Appropriate extent of thyroidectomy for patients with low-risk thyroid medical treatment remains dynamic and might include active surveillance, thyroid lobectomy, or total thyroidectomy.

- Given the excellent outcomes for most patients with differentiated thyroid medical treatment, patient preference and a robust discussion regarding options for the extent of surgery and long-term surveillance are critical.
- Referring providers, payers, and policymakers should be aware of the implications of the association between surgeon volume and patient outcomes so that patient access to experienced thyroid surgeons can be optimized.
- Finally, combination therapeutic strategies targeting multiple components of the Modern Thyroidectomy simultaneously may represent the most effective approach for overcoming immune resistance and improving long-term clinical outcomes in medical treatment immunotherapy. Molecular testing for indeterminate thyroid nodules continues to evolve and guide recommendations for the extent of thyroid surgery.

## 7. Recommendations

Based on the results of this study, we recommend the introduction of surgical techniques using modern energy devices whenever possible for thyroidectomy. This is expected to improve surgical efficiency, reduce intraoperative blood loss, and suppress the incidence of postoperative hypocalcemia. Furthermore, to evaluate long-term functional recovery and quality of life in patients, it is desirable to actively incorporate patient-reported outcomes, including vocal function, scar satisfaction, QOL, and TSOS, into postoperative follow-up. In addition, because this is a retrospective study with a limited 6-month follow-up period, the implementation of prospective, multicenter, collaborative studies and long-term follow-up studies to verify these results is recommended. This is expected to establish stronger evidence regarding the long-term efficacy and safety of modern thyroidectomy.

## Ethical Considerations

This study was approved by the Al-Nasiriyah Teaching Hospital Ethics Review Committee (Approval No.: 266). As this was a retrospective study using anonymized existing medical records, written informed consent was waived. All study procedures were performed in accordance with the ethical principles of the Declaration of Helsinki [12].

**List of Abbreviations:** STROBE: Strengthening the Reporting of Observational Studies in Epidemiology; CT: conventional thyroidectomy; MIVAT: minimally invasive video-assisted thyroidectomy; TSOS: Thyroid Surgery Outcome Score; VAS: Visual Analog Scale;

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**Declaration of generative AI and AI-assisted technologies in the writing process**

The authors hereby declare that no generative artificial intelligence or AI-assisted technologies were used at any stage during the preparation of this manuscript, including language editing, proofreading, or content development. The authors take full responsibility for the originality and integrity of the work presented in this publication.

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