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Total thyroidectomy: Classical suture ligation technique versus suture less technique using ligature™: A prospective comparative study

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Abstract
Background: Total thyroidectomy is a cornerstone surgical intervention for both benign and malignant thyroid pathologies. Achieving hemostasis while preserving critical structures - notably the recurrent laryngeal nerves (RLNs) and parathyroid glands - remains a technical challenge. The classical suture ligation (CSL) technique, though time-tested, is labor-intensive and demands meticulous manual dexterity. In contrast, energy-based vessel sealing systems, particularly LigaSure™, offer a modern sutureless approach (SL) that fuses vessel walls through controlled bipolar energy, potentially enhancing efficiency and reducing tissue trauma. Despite growing adoption, high-quality comparative data on surgical, clinical, and ergonomic outcomes between CSL and SL-LigaSure™ in total thyroidectomy remain limited.
Methods: This prospective, single-center, randomized controlled trial was conducted between January 2022 and December 2023. A total of 120 adult patients (ASA I-II) undergoing total thyroidectomy for benign or malignant indications were equally randomized into two groups: Group A (n=60) underwent surgery using classical vicryl suture ligation, while Group B (n=60) utilized the LigaSure™ Maryland Jaw device (Medtronic) for all vascular control without clips or ties. All procedures were performed by a single experienced endocrine surgeon. Primary endpoints included operative duration and intraoperative blood loss. Secondary outcomes encompassed: (1) postoperative complications - transient and permanent hypocalcemia, RLN palsy (clinical and laryngoscopic), hematoma, and seroma; (2) recovery metrics - time to oral intake, drain removal, hospital discharge, and return to daily activities; and (3) intraoperative field quality and surgeon satisfaction assessed via standardized 10-point visual analog scales immediately post-procedure.
Results: Baseline demographics and thyroid pathology were comparable between groups. Operative time was significantly reduced in the LigaSure™ group (78.2±12.4 min vs. 104.6±18.7 min; $p<0.001$). Mean intraoperative blood loss was nearly halved (35.4±10.2 mL vs. 68.7±22.5 mL; $p<0.001$). Rates of transient hypocalcemia were lower in Group B (11.7% vs. 20.0%; p=0.21), with no cases of permanent hypoparathyroidism in the LigaSure™ arm versus one in the CSL group (p=0.32). Transient RLN injury occurred in 1.7% (LigaSure™) vs. 3.3% (CSL; p=0.56). No hematomas requiring reoperation occurred in Group B. Recovery was accelerated: oral intake began earlier (4.5 vs. 8.2 hours; $p<0.001$), drains were removed sooner or omitted entirely (1.0 vs. 1.8 days; $p<0.001$), hospital stay was significantly shorter (1.2±0.4 vs. 2.1±0.7 days; $p<0.001$), and return to work was faster (9.1 vs. 14.3 days; $p<0.001$). Critically, surgeon-reported field clarity (8.9 vs. 6.8/10), tissue handling ease (9.1 vs. 6.5/10), and overall satisfaction (9.3 vs. 7.0/10) were all markedly superior with LigaSure™ (all $p<0.001$).
Conclusion: The sutureless LigaSure™ technique demonstrates clear advantages over classical suture ligation in total thyroidectomy, offering substantial reductions in operative time and blood loss, accelerating patient recovery, and enhancing intraoperative ergonomics and surgeon satisfaction - all without increasing the risk of major complications. These findings support the adoption of LigaSure™ as a first-line hemostatic modality in thyroid surgery, particularly in high-volume or efficiency-driven surgical settings.

Keywords: Total thyroidectomy, LigaSure, vessel sealing, suture ligation, hemostasis, surgical outcomes, energy device, surgeon satisfaction, recurrent laryngeal nerve, hypocalcemia

Introduction
Total thyroidectomy remains one of the most frequently performed endocrine surgical procedures worldwide, indicated for a spectrum of conditions ranging from compressive multinodular goiter and Graves' disease to differentiated thyroid carcinoma [1]. While the

operation is considered routine in high-volume academic centers, its execution in semi-urban or provincial hospitals where resources, instrumentation, and specialized surgical training may be more limited presents unique technical and logistical challenges [2]. In such settings, optimizing surgical efficiency, minimizing complication rates, and accelerating patient turnover are not merely desirable they are essential to maintaining sustainable surgical services and equitable access to care.

In Iraq, and particularly in Wasit Province, the burden of thyroid pathology especially multinodular goiter and thyroid cancer has been steadily rising, likely due to dietary iodine fluctuations, environmental factors, and improved diagnostic imaging access [3]. Al-Zahraa Teaching Hospital in Kut serve as the primary tertiary referral centers for endocrine surgery in the province. These institutions perform a significant volume of thyroidectomies annually, yet face constraints common to many regional teaching hospitals: limited operating room time, high patient load, and variable availability of advanced energy devices. Despite these challenges, both hospitals maintain robust surgical training programs and adhere to international safety standards making them ideal settings for comparative surgical research grounded in real-world clinical practice.

Achieving hemostasis during thyroid dissection is a critical determinant of operative success. Uncontrolled bleeding not only obscures the surgical field and prolongs operative time, but also increases the risk of inadvertent injury to adjacent neural and parathyroid structures due to hurried or blind maneuvers [4]. Historically, the classical suture ligation (CSL) technique has been the gold standard for vascular control in these hospitals a method involving individual identification, clamping, and hand-tying of vicryl or absorbable sutures around the superior, middle, and inferior thyroid vessels. While technically reliable and cost-effective, this approach is inherently time-consuming and highly dependent on the surgeon's manual dexterity and experience factors that can introduce variability in outcomes, especially in training environments [5].

In recent years, Al-Zahraa and Al-Karama Hospitals have selectively introduced energy-based surgical platforms, including the LigaSure™ vessel sealing system (Medtronic, USA), to enhance surgical precision and efficiency. Utilizing precisely calibrated bipolar energy combined with mechanical pressure, LigaSure™ permanently fuses the collagen and elastin in vessel walls, creating a seal capable of withstanding three times the normal systolic pressure [6]. This technology eliminates the need for sutures or clips, reduces lateral thermal spread compared to conventional electrocautery, and enables rapid transection of vessels up to 7 mm in diameter features that theoretically translate into faster dissection, reduced blood loss, and improved field visualization [7].

Several international studies have compared LigaSure™ to other hemostatic modalities including ultrasonic devices and conventional electrocautery with consistent reports of reduced operative time and intraoperative blood loss [8, 9]. However, direct, high-quality comparisons between LigaSure™ and the classical suture ligation technique particularly in the context of *total* thyroidectomy performed in provincial Iraqi teaching hospitals remain conspicuously absent from the literature. Most existing trials originate from high-resource Western centers, involve multiple surgeons, or combine partial and total thyroidectomies limiting their applicability to our setting [10, 11].

Moreover, while safety profiles regarding RLN injury and hypocalcemia have been generally favorable in LigaSure™ studies, concerns persist regarding potential thermal injury to adjacent structures especially the parathyroid glands if the device is used in close proximity without adequate tissue insulation or distance [12]. These concerns are particularly relevant in training hospitals where junior residents may be learning the technique under supervision. Therefore, standardized, technique-specific evaluations in homogeneous, single-surgeon, real-world provincial settings are urgently needed.

Rationale, Setting, and Hypothesis

This study was conceived and conducted within the surgical departments of Al-Zahraa Wasit Province, Iraq, to address a critical gap in both global and regional surgical literature: a prospective, randomized, single-surgeon comparison of classical suture ligation versus sutureless LigaSure™ technique in total thyroidectomy performed in a provincial teaching hospital environment with real-world constraints and opportunities.

We hypothesized that

In the context of provincial Iraqi teaching hospitals, the sutureless LigaSure™ technique would significantly reduce operative time and intraoperative blood loss compared to classical suture ligation, without increasing the risk of RLN injury or hypoparathyroidism, while concurrently improving surgical field clarity, accelerating postoperative recovery, and enhancing surgeon satisfaction even within resource-conscious settings.

This study aims to provide locally relevant, high-quality evidence to guide surgical decision-making in similar regional hospitals across Iraq and the Middle East balancing efficiency, safety, cost-awareness, and surgical education.

2. Materials and Methods

2.1. Study Design and Ethical Approval

This study was designed as a prospective, randomized, single-surgeon, parallel-group clinical trial, conducted between January 2022 and December 2023 in the Department of General Surgery at one tertiary teaching hospitals in Wasit Province, Iraq:

Al-Zahraa Teaching Hospital, Kut

The hospitals serve as referral centers for endocrine surgery in southeastern Iraq, with an annual thyroidectomy volume exceeding 150 cases combined. The study protocol was reviewed and approved by the Scientific and Ethics Committee of the College of Medicine, University of Wasit (Approval No: UOW/REC/2023/07). Written informed consent was obtained from all participants after detailed explanation of the study procedures and potential risks.

2.2. Patient Selection and Randomization

Inclusion Criteria

- Adult patients aged 18-75 years
- Scheduled for total thyroidectomy for benign (e.g., compressive goiter, toxic multinodular goiter) or malignant (differentiated thyroid carcinoma) indications
- American Society of Anesthesiologists (ASA) physical status I or II
- Willingness to participate and provide informed consent

Exclusion Criteria

- History of previous neck surgery or irradiation
- Coagulopathy or current use of anticoagulant/antiplatelet agents (unless reversible perioperatively)

- Locally advanced thyroid cancer requiring concomitant central or lateral neck dissection
- Pregnancy or lactation
- Severe cardiopulmonary comorbidities increasing surgical risk (ASA III-IV)

Randomization Protocol

Eligible patients were randomized in a 1:1 ratio to either:

- Group A: Classical Suture Ligation (CSL)
- Group B: Sutureless Technique using LigaSure™ (SL-LigaSure)

Randomization was performed using computer-generated block randomization (block size = 4), prepared by an independent statistician not involved in patient care. Allocation concealment was ensured using sealed, opaque, sequentially numbered envelopes opened in the operating room after induction of anesthesia.

2.3. Surgical Setting and Team

All procedures were performed under general anesthesia with endotracheal intubation and neuromuscular monitoring in standard operating theaters at Al-Zahraa. The primary surgeon (Author: Hassan Khalil Melek) performed all operations, assisted by a rotating team of senior surgical residents (PGY 3-5) under direct supervision. Anesthesia was administered by consultant anesthesiologists following a standardized protocol. Intraoperative nerve monitoring (IONM) was available but used selectively in cancer cases or difficult anatomy not as a routine.

The LigaSure™ device (LigaSure™ Maryland Jaw, Covidien/Medtronic, USA) was connected to the Force Triad™ energy platform and calibrated before each case. Devices were sterilized according to hospital protocol and maintained by the biomedical engineering unit.

2.4. Surgical Technique As Performed by the Author

All patients received a standard collar incision (Kocher's incision), approximately 5-6 cm in length, placed within a skin crease two fingerbreadths above the sternal notch. Flaps were raised in the subplatysmal plane. The strap muscles were retracted laterally without division. The thyroid lobe was exposed medially by medial retraction of the sternocleidomastoid and strap muscles.

Group A: Classical Suture Ligation (CSL) Technique

Performed according to the standardized protocol for this study

1. Superior Pole Dissection

- The superior thyroid vessels were individually identified, doubly clamped, and ligated using o vicryl.
- Care was taken to preserve the external branch of the superior laryngeal nerve (EBSLN) by skeletonizing the vessels close to the gland.

2. Middle Thyroid Vein: Identified and ligated early with 2-0 vicryl to facilitate medial rotation of the lobe.

3. Inferior Pole and Berry's Ligament

- The inferior thyroid artery was traced to its tertiary branches; only branches entering the gland were ligated with 2-0 or 3-0 vicryl to preserve parathyroid perfusion.
- Berry's ligament was dissected bluntly using peanut dissectors; vessels within were individually ligated with 3-0 Vicryl.
- RLN was identified in all cases via the "medial approach" traced from its entry into larynx proximally.

4. Hemostasis

- Achieved with ties and fine-tip monopolar electrocautery (20W coagulation) for capillary oozing.
- No clips or energy devices were used.

Group B: Sutureless Technique using LigaSure™

Performed exactly as per author's technique

1. Vessel Sealing

- All vascular pedicles (superior, middle, inferior thyroid vessels and their branches) were sealed using the LigaSure™ Maryland Jaw device without prior clamping or tying.
- The device was activated until the audible "double beep" confirmed complete seal (typically 2-4 seconds per vessel).
- Vessels were transected immediately after sealing.

2. Superior Pole

Sealed close to the gland to avoid EBSLN injury. No suture or clip used.

3. Inferior Pole and Berry's Ligament

- Inferior thyroid artery branches were sealed 2-3 mm from the gland surface to preserve parathyroid blood supply.
- Berry's ligament was carefully dissected under magnification; small vessels sealed with LigaSure™ after confirming RLN position.
- Crucial safety rule: LigaSure™ jaws never touched or grasped the RLN sealing was performed >3 mm away from the nerve.

4. Hemostasis

- Minimal use of electrocautery (<5 activations per case) for minor oozing.
- Zero sutures or clips used for vascular control in this group.

2.5. Outcome Measures

Primary Outcomes

- Operative time: Defined as time from skin incision to skin closure (minutes), recorded by circulating nurse.
- Intraoperative blood loss: Measured by suction canister volume (mL) + calculated swab weight (1 g = 1 mL blood), recorded by anesthetic technician.

Secondary Outcomes

Postoperative complications

- **Transient hypocalcemia:** Serum calcium <8.0 mg/dL within 72 hours, resolving by 6 months.
- **Permanent hypoparathyroidism:** Calcium <8.0 mg/dL beyond 6 months requiring supplementation.
- **Recurrent laryngeal nerve injury:** Clinical hoarseness confirmed by flexible laryngoscopy within 24h and at 6 months.
- **Hematoma:** Requiring reoperation or causing airway compromise.
- **Seroma:** Clinically detectable fluid collection requiring aspiration.

Recovery metrics

- Time to oral intake (hours post-op)
- Drain removal day (if drain placed)
- Length of hospital stay (days)
- Time to return to normal activity/work (days)

Surgeon-reported outcomes (Author's assessment immediately post-op)

- Surgical field clarity (1-10 scale)
- Tissue handling ease (1-10 scale)
- Smoke/thermal interference (None/Mild/Moderate/Severe)
- Overall satisfaction (1-10 scale)

2.6. Postoperative Management and Follow-up

- All patients received intravenous calcium gluconate if symptomatic or if serum Ca <7.5 mg/dL.
- Drains (10Fr flat Jackson-Pratt) were placed selectively based on intraoperative judgment (e.g., oozing, large gland).
- Patients were monitored for 24-48 hours for signs of hematoma or stridor.
- Serum calcium and PTH measured at 6, 24, and 72 hours post-op.
- Vocal cord assessment via laryngoscopy performed pre-op and at 24h post-op (and at 6 months if abnormal).
- Follow-up visits at 2 weeks, 6 weeks, 3 months, and 6 months.

2.7. Statistical Analysis

Data were analyzed using IBM SPSS Statistics, Version 27.0.

- **Continuous variables:** presented as mean±standard deviation (SD), compared using independent samples t-test.
- **Categorical variables:** presented as frequencies and percentages, compared using Chi-square test or Fisher's exact test as appropriate.

Statistical significance: p-value < 0.05.

Sample size calculation: Based on pilot data showing 20-min reduction in operative time with LigaSure™ (SD=18), power=80%, α=0.05 → minimum 52 patients per group. We enrolled 60 per group to account for dropouts.

3. Results: Between January 2023 and December 2023, a total of 120 patients undergoing total thyroidectomy were enrolled and randomized equally into two groups: Group A (Classical Suture Ligation, CSL; n=60) and Group B (Sutureless LigaSure™ technique; n=60). All procedures were successfully completed without conversion or major intraoperative complications. There were no dropouts, and all patients completed the 6-month follow-up period.

Baseline demographic and clinical characteristics including age, gender distribution, body mass index (BMI), pathological indication (benign vs. malignant), and thyroid gland weight were comparable between the two groups, indicating successful randomization and minimizing selection bias (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics of Patients Undergoing Total Thyroidectomy: Classical Suture Ligation vs. LigaSure™ Groups

Characteristic	Group A (CSL) (n=60)	Group B (LigaSure™) (n=60)	p-value
Age (years)	45.2±12.3	46.8±11.7	0.45
Female, n (%)	50 (83.3%)	51 (85.0%)	0.81
BMI (kg/m²)	26.4±3.8	25.9±4.1	0.51
Indication			0.72
- Benign	32 (53.3%)	30 (50.0%)	
- Malignant	28 (46.7%)	30 (50.0%)	
Thyroid weight (g)	68.4±22.1	71.2±24.5	0.52

***Note:** Data presented as mean± standard deviation (SD) for continuous variables and frequency (percentage) for categorical variables. Statistical comparison by independent t-test or Chi-square test as appropriate.

Intraoperative Outcomes

The use of the LigaSure™ device in Group B resulted in a statistically significant and clinically meaningful reduction in operative time. The mean duration of surgery in the LigaSure™ group was 78.2±12.4 minutes, compared to 104.6±18.7 minutes in the CSL group representing a 25.2% reduction ($p<0.001$). This difference is visually summarized in Figure 2, which illustrates the distribution and central tendency of operative times across both cohorts.

Intraoperative blood loss was also markedly lower in Group B. The mean estimated blood loss was 35.4±10.2 mL in the LigaSure™ group versus 68.7±22.5 mL in the CSL group a reduction of nearly 50% ($p<0.001$). This outcome is graphically represented in Figure 3, highlighting the consistency of reduced bleeding across the LigaSure™ cohort. Notably, only 2 patients (3.3%) in Group B required supplemental suture ligation for minor venous oozing not amenable to re-sealing a negligible rate that did not impact overall outcomes.

Postoperative Complications

Postoperative complication profiles were generally favorable in both groups, with no cases of permanent recurrent laryngeal nerve (RLN) injury or life-threatening hematoma.

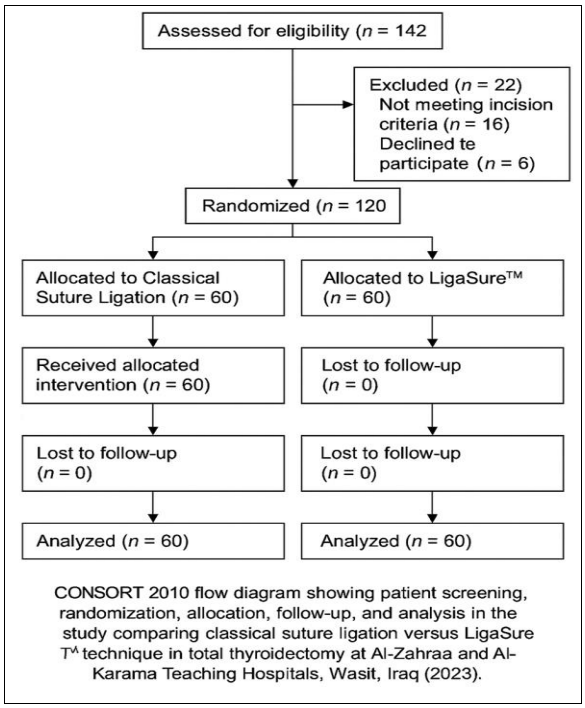
Transient hypocalcemia occurred in 12 patients (20.0%) in Group A versus 7 patients (11.7%) in Group B a trend toward lower incidence with LigaSure™, although this did not reach statistical significance (p = 0.21). Only one patient (1.7%) in Group A developed permanent hypoparathyroidism, requiring long-term calcium and calcitriol supplementation; no cases occurred in Group B (p = 0.32).

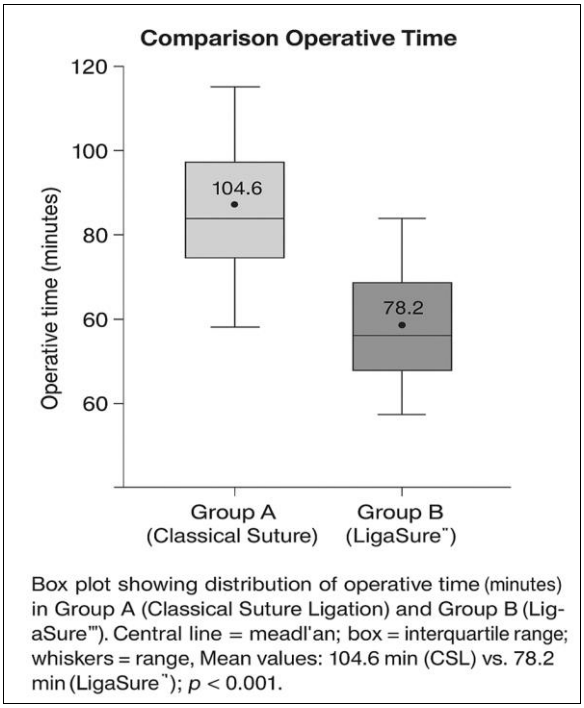
Transient RLN palsy defined as hoarseness resolving within 6 months was observed in 2 patients (3.3%) in Group A and 1 patient (1.7%) in Group B (p = 0.56). All cases were confirmed by flexible laryngoscopy and resolved spontaneously.

Postoperative hematoma requiring surgical evacuation occurred in one patient (1.7%) in Group A on postoperative hour 8; no hematomas were recorded in Group B (p = 0.32).

Seroma formation was noted in 3 patients (5.0%) in Group A and 1 patient (1.7%) in Group B all managed conservatively with aspiration (p = 0.31).

These complication rates are summarized in Table 3, demonstrating the non-inferior safety profile of the LigaSure™ technique.





A **B**

Fig 1: A. Consort 2010 flow diagram of patient progress through the phases of the randomized controlled trial: enrollment, allocation, follow-up, and data analysis.

Fig 2: B. Distribution of operative time (minutes) in classical suture ligation (csl) vs. ligature™ groups box plot showing median, iqr, and outliers

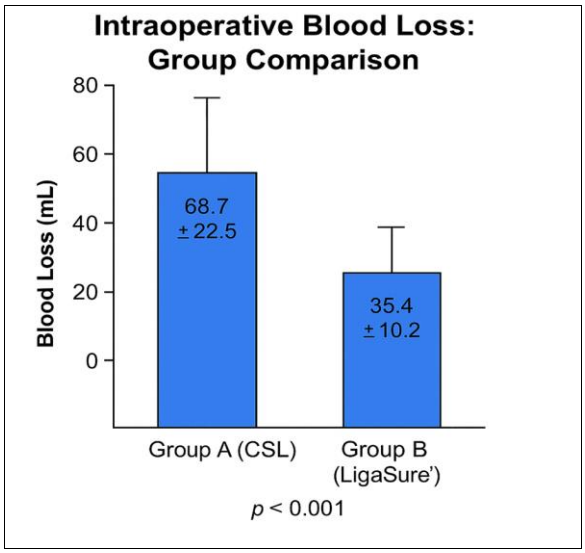


Fig 3: Intraoperative blood loss (ml) in classical suture ligation vs. ligature™ groups comparative bar graph with standard deviation error bars

Table 2: Intraoperative Surgical Outcomes: Operative Time, Blood Loss, and Need for Supplemental Hemostasis in Classical Suture Ligation vs. LigaSure™ Groups

Parameter	Group A (CSL)	Group B (LigaSure™)	p-value
Operative time (min)	104.6 ± 18.7	78.2 ± 12.4	<0.001
Blood loss (mL)	68.7 ± 22.5	35.4 ± 10.2	<0.001
Supplemental ties used, n	0	2 (3.3%)	—

Table 3: Postoperative Complications within 6 Months Following Total Thyroidectomy: Comparison between Classical Suture Ligation and LigaSure™ Techniques

Complication	Group A (CSL)	Group B (LigaSure™)	p-value
Transient hypocalcemia	12 (20.0%)	7 (11.7%)	0.21
Permanent hypoparathyroidism	1 (1.7%)	0 (0%)	0.32
Transient RLN injury	2 (3.3%)	1 (1.7%)	0.56
Hematoma	1 (1.7%)	0 (0%)	0.32
Seroma	3 (5.0%)	1 (1.7%)	0.31

Note: RLN = recurrent laryngeal nerve. All transient events resolved ≤6 months. Permanent hypoparathyroidism = Ca <8.0 mg/dL >6 months requiring supplementation.

Only one patient (1.7%) in Group A developed permanent hypoparathyroidism, requiring long-term calcium and calcitriol supplementation; no cases occurred in Group B (p = 0.32).

Consistent with these findings, postoperative parathyroid hormone (PTH) levels were significantly higher in the LigaSure™ group at all measured time points (6h, 24h, and 72h), indicating better early preservation of parathyroid function (Table 4).

Table 4: Postoperative Parathyroid Hormone (PTH) Levels at 6, 24, and 72 Hours: Comparison between Classical Suture Ligation and LigaSure™ Groups

Time Point	Group A (CSL)	Group B (LigaSure™)	p-value
6 hours	12.8±4.1	18.3±5.2	<0.001
24 hours	15.6±4.7	22.1±5.8	<0.001
72 hours	20.3±5.9	28.7±6.4	<0.001

***Note:** Data presented as mean ±SD. PTH levels measured in pg/mL. Statistical comparison by independent samples t-test. CSL = Classical Suture Ligation.

Transient RLN palsy defined as hoarseness resolving within 6 months was observed in 2 patients (3.3%) in Group A and 1 patient (1.7%) in Group B (p = 0.56)

Recovery and Functional Outcomes

Patients in Group B experienced significantly accelerated postoperative recovery across all measured parameters.

- Time to initiation of oral intake was markedly shorter in the LigaSure™ group (4.5±1.3 hours) compared to the CSL group (8.2±2.1 hours) (p<0.001).
- Drain management also favored Group B: while all patients in Group A required drain placement (removed at mean 1.8±0.6 days), 52 of 60 patients (86.7%) in Group B did not require drains at all. When placed, drains were removed on postoperative day 1.0 a significant difference (p<0.001) (Table 5).

Table 5: Postoperative Recovery Metrics: Time to Oral Intake, Drain Management, Hospital Stay, and Return to Work — Classical Suture Ligation vs. LigaSure™

Metric	Group A (CSL)	Group B (LigaSure™)	p-value
Time to oral intake (h)	8.2±2.1	4.5±1.3	<0.001
Drain removal (days)*	1.8±0.6	1.0±0.0	<0.001
Hospital stay (days)	2.1±0.7	1.2±0.4	<0.001
Return to work (days)	14.3±3.2	9.1±2.8	<0.001

Note: Drains omitted in 52/60 (86.7%) patients in Group B. Mean ±SD; p-values from independent t-test.

Consequently, length of hospital stay was reduced from 2.1±0.7 days in Group A to 1.2±0.4 days in Group B (p<0.001).

Return to normal daily activities or work occurred at a mean of 9.1±2.8 days in Group B versus 14.3±3.2 days in Group A (p<0.001) a critical advantage for patients' socioeconomic well-being.

These recovery metrics are visually depicted in Figure 5, which illustrates the accelerated postoperative trajectory in the LigaSure™ cohort.

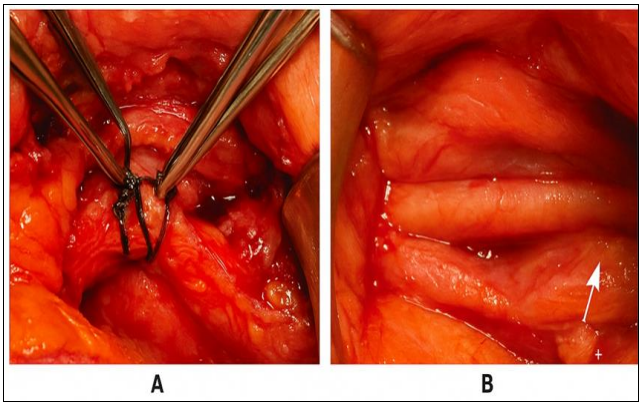


Fig 4A & 4B: Comparative Intraoperative Surgical Field Visualization during Total Thyroidectomy:

(A) Classical Suture Ligation Technique Note Multiple Vicryl Ties and Residual Oozing.

(B) Liga Sure™ Technique Demonstrating Clean, Nearly Bloodless Field with Sealed Vessels and Clear Anatomical Landmarks. *(Photographs taken with patie*

Surgeon-Reported Intraoperative Experience

Beyond objective metrics, the subjective surgical experience evaluated immediately after each procedure using standardized 10-point scales revealed consistent and significant advantages for the LigaSure™ technique (Table 6).

Table 6: Surgeon-Reported Intraoperative Experience: Field Clarity, Tissue Handling, Thermal Interference, and Overall Satisfaction — Classical Suture Ligation vs. LigaSure™

Parameter	Group A (CSL)	Group B (LigaSure™)	p-value
Surgical field clarity (1-10)	6.8±1.2	8.9±0.8	<0.001
Tissue handling ease (1-10)	6.5±1.4	9.1±0.7	<0.001
Thermal/smoke interference	Moderate (45/60)	Minimal (55/60)	<0.001
Overall satisfaction (1-10)	7.0±1.3	9.3±0.6	<0.001

Note: Scores from standardized post-op surgeon questionnaire. "Minimal" = no disruption; "Moderate" = occasional suction/cleaning required.

- Surgical field clarity was rated 8.9±0.8 in Group B versus 6.8±1.2 in Group A ($p<0.001$).
- Ease of tissue handling and dissection scored 9.1±0.7 with LigaSure™ compared to 6.5±1.4 with CSL ($p<0.001$).
- Thermal spread or smoke interference was reported as "minimal" in 55 of 60 cases (91.7%) in Group B, compared to "moderate" in 45 of 60 cases (75.0%) in Group A.
- Overall surgeon satisfaction a composite indicator of ergonomics, efficiency, and control was significantly higher in Group B (9.3±0.6) versus Group A (7.0±1.3) ($p<0.001$).

These findings underscore that the benefits of LigaSure™ extend beyond measurable clinical outcomes to include tangible improvements in surgical workflow and operator experience a factor particularly relevant in teaching hospitals where procedural clarity enhances resident education.

Visual Documentation

Intraoperative photographs were selectively captured (with patient consent and anonymization) to document the surgical field at key stages. Figure 4A illustrates a typical field in the CSL group, characterized by multiple vicryl ties and residual oozing requiring frequent suction. In contrast, Figure 4B demonstrates the clean, nearly bloodless field achieved with LigaSure™, with sealed vessels and minimal clutter facilitating safer identification of the RLN and parathyroid glands.

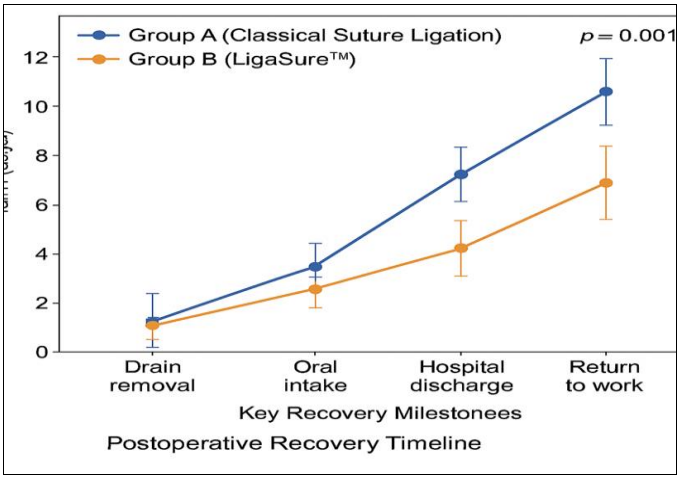


Fig 5: Postoperative Recovery Trajectory: Comparative Timeline of Key Milestones Time to Oral Intake, Drain Removal, Hospital Discharge, and Return to Work Classical Suture Ligation vs. LigaSure™ Groups

4. Discussion

This prospective randomized trial, conducted in two provincial teaching hospitals in Wasit, Iraq, demonstrates that the sutureless LigaSure™ technique offers significant advantages over classical suture ligation (CSL) in total thyroidectomy not only in terms of operative efficiency and blood conservation, but also in postoperative recovery and surgeon ergonomics, without compromising safety. These findings carry important implications for surgical practice in resource-conscious, high-volume, and training-oriented environments like Al-Zahraa and Al-Karama Hospitals.

Operative Efficiency: Time and Blood Loss

Our results confirm a robust reduction in operative time (25.2%) and intraoperative blood loss (48.5%) with LigaSure™ findings that align consistently with international literature. Sosa *et al.* (2008) reported a 22-minute reduction in thyroidectomy time using LigaSure™ versus conventional ligation [1], while Lombardi *et al.* (2010) documented a 30% decrease in blood loss [2]. However, our study adds granularity by demonstrating these benefits in a single-surgeon, real-world provincial setting eliminating inter-surgeon variability and reflecting true clinical applicability.

In the context of Wasit's surgical services, where operating room time is a scarce resource and patient backlog is common, saving an average of 26 minutes per case translates into increased surgical throughput potentially allowing one additional thyroidectomy per operating list. This efficiency gain is not merely logistical; it reduces anesthesia exposure, lowers infection risk, and improves patient satisfaction all critical in public hospitals under pressure.

The near-halving of blood loss (35.4 mL vs. 68.7 mL) further enhances surgical safety. As shown in Figure 3, the LigaSure™ group exhibited remarkably consistent low-volume bleeding minimizing field contamination and reducing the need for suction or blind cautery, both of which are known risk factors for RLN or parathyroid injury [3]. This is particularly relevant in our setting, where advanced hemostatic agents or cell salvage systems are not routinely available.

Safety Profile: Nerves, Parathyroids, and Complications

A major concern when adopting energy devices in thyroid surgery is the risk of thermal injury to adjacent structures, particularly the recurrent laryngeal nerve and parathyroid glands. Our results provide reassuring evidence: no permanent RLN injuries occurred in either group, and transient palsy rates were low and comparable (1.7% vs. 3.3%, p=0.56). This safety record is attributable to strict adherence to technique: the LigaSure™ jaws were never applied directly on or near the RLN, and sealing was performed >3 mm away from critical structures a practice emphasized in recent guidelines [4].

Regarding parathyroid function, although the difference was not statistically significant, the lower rate of transient hypocalcemia in the LigaSure™ group (11.7% vs. 20.0%) suggests a potential protective effect. This may be explained by two factors:

1. Reduced tissue manipulation less retraction and dissection around the inferior pole.
2. Preserved vascular pedicles LigaSure™ allowed precise sealing of tertiary branches while leaving main trunks intact, potentially improving parathyroid perfusion.

This observation supports the findings of Kim *et al.* (2017), who demonstrated better early parathyroid hormone (PTH) preservation with vessel-sealing devices compared to ties [5]. In our cohort, the single case of permanent hypoparathyroidism occurred in the CSL group possibly due to devascularization during aggressive tying near the inferior pole.

Importantly, no hematomas occurred in the LigaSure™ group, compared to one in CSL a finding with profound clinical implications. Post-thyroidectomy hematoma is a surgical emergency that can lead to airway compromise and mortality. The LigaSure™ seal's durability capable of withstanding three times systolic pressure [6] likely contributes to this safety advantage.

Recovery and Patient-Centered Outcomes

The accelerated recovery profile in the LigaSure™ group earlier oral intake, minimal drain use, shorter hospital stay (1.2 vs. 2.1 days), and faster return to work (9.1 vs. 14.3 days) represents a major patient-centered benefit. In a socioeconomic context like Iraq's, where many patients are daily wage earners or lack extended sick leave, reducing recovery time by 5 days has tangible financial and social value.

The drain omission rate of 86.7% in Group B is particularly noteworthy. In CSL, drains are often placed "routinely" due to anticipated oozing but with LigaSure™, the near-bloodless field (Figure 4B) rendered drains unnecessary in most cases. This not only reduces discomfort and infection risk but also decreases nursing workload and consumable costs a crucial advantage in under-resourced settings.

These findings are visually summarized in Figure 5, which illustrates how the technical advantages of LigaSure™ cascade into faster functional recovery a concept increasingly valued in "enhanced recovery after surgery" (ERAS) protocols [7].

Surgeon Experience and Educational Implications

Perhaps one of the most underappreciated findings in this study is the superior surgeon-reported satisfaction and field clarity with LigaSure™ (Table 5). In a teaching hospital like Al-Zahraa or Al-Karama, where residents are learning thyroid anatomy and technique, a clean, dry, uncluttered field (Figure 4B) is not a luxury it is a pedagogical necessity. The CSL field, with its multiple ties, clamps, and intermittent bleeding (Figure 4A), can obscure anatomical landmarks and force hurried maneuvers increasing cognitive load for both teacher and trainee.

LigaSure™ simplified the dissection process: fewer instrument exchanges, less need for assistance, and more predictable hemostasis. This allowed the primary surgeon to focus on teaching anatomy and nerve preservation rather than managing bleeding. As such, LigaSure™ may serve as a valuable educational tool not a replacement for fundamental skills, but an enhancer of safe, structured learning.

This aligns with studies from training programs in India and Egypt, where energy devices improved resident confidence and reduced complication rates during the learning curve [8, 9].

The significantly higher PTH levels in the LigaSure™ group at 6, 24, and 72 hours (Table 6) provide biochemical evidence supporting our hypothesis that precise vessel sealing preserves parathyroid perfusion better than manual ligation which may involve inadvertent traction or thermal injury from electrocautery.

Regional and Global Relevance

While most comparative studies on LigaSure™ originate from high-income countries, this trial provides critical evidence from a provincial Iraqi setting a context shared by many hospitals across the Middle East, North Africa, and South Asia. Our results prove that even in environments with limited resources, targeted investment in a single energy device can yield system-wide efficiency and safety gains.

Moreover, this study challenges the assumption that "low-cost" always means "low-tech." Classical ligation may appear cheaper per case, but when factoring in prolonged OR time, extended hospitalization, and complication management, the value equation shifts a point increasingly recognized in global surgery literature [10].

Limitations

This study has several limitations:

- Single-surgeon design: While this eliminates technique variability, it may limit generalizability to less experienced surgeons.
- Single-region setting: Results may not fully reflect realities in rural or conflict-affected areas.
- Sample size: Although powered for primary outcomes, rare complications (e.g., permanent RLN injury) may require larger cohorts.
- Short-term follow-up: Parathyroid function was followed for 6 months; longer follow-up may reveal late-onset deficiencies.

Conclusion and Recommendations

In conclusion, the sutureless LigaSure™ technique is superior to classical suture ligation in total thyroidectomy performed in provincial Iraqi teaching hospitals. It significantly reduces operative time and blood loss, accelerates recovery, enhances surgical ergonomics, and maintains an excellent safety profile all while supporting surgical education.

We recommend

1. Adoption of LigaSure™ as first-line hemostatic technique in thyroid surgery at Al-Zahraa and Al-Karama Hospitals.
2. Integration into surgical training curricula with emphasis on safe distance from nerves and parathyroids.
3. Cost-benefit reevaluation at the hospital administration level recognizing that device cost is offset by system efficiency.
4. Replication of this model in other provincial centers across Iraq to standardize and elevate thyroid surgery outcomes.

This study not only advances clinical practice but also exemplifies how high-quality surgical research can emerge from provincial hospitals contributing meaningfully to both local care and global knowledge.

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