Original Article

Comparison of thyroid surgery techniques: a retrospective cohort study and meta-analysis of traditional electric knife *vs.* straight bipolar electrocoagulation forceps

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Background: In recent years, advancements in surgical techniques for thyroidectomy have led to varying outcomes and efficiencies. Understanding these differences is crucial to optimize patient care and surgical success. This study compared intra- and postoperative parameters of thyroid surgery for thyroidectomy or thyroid cancer. One approach involved the traditional electric knife, employing traditional clamp-ligation skills and an electric knife. The other approach utilized straight bipolar electrocoagulation forceps for micro-hemostasis and micro-cutting.

Methods: Data were analyzed retrospectively for 228 patients who underwent thyroidectomy at the Third Affiliated Hospital of Kunming Medical University from January 2014 to November 2018. Surgery was performed either as traditional open surgery (n=150) or as a meticulous anatomical procedure involving bipolar electrocoagulation (n=78). In addition, data from published studies comparing the two surgical procedures were meta-analyzed.

Results: The bipolar electrocoagulation procedure was associated with significantly shorter total operation time, lower intraoperative blood loss and lower rate of hypocalcemia. The two procedures were associated with similar rates of hoarseness. Meta-analysis of eight studies involving 2,080 patients showed that bipolar electrocoagulation was associated with significantly shorter total operation time than the traditional approach (mean difference =–21.29 min, 95% CI: –26.32 to –16.27) and with less intraoperative bleeding (mean difference =–12.87 min, 95% CI: –23.81 to –1.93).

Conclusions: Straight bipolar electrocoagulation forceps can be used to perform fine dissection during thyroid surgery. Performing "micro-hemostasis" and "micro-cutting" manipulations with these straight bipolar forceps can smoothly dissect nerves and parathyroid glands and may reduce intraoperative bleeding, operation time and rates of postoperative complications, might accelerate recovery after surgery.

Keywords: Thyroid surgery; traditional electric knife; bipolar electrocoagulation; rapid postoperative recovery; meta-analysis

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Introduction

Thyroid tumors are common diseases affecting the head and neck (1,2), and they are treated primarily through surgery (3-6). Although the surgical procedures can be performed to a reasonable degree in most hospitals, differences in surgical skill and instrumentation can affect the risk of excessive bleeding, recurrent laryngeal nerve, parathyroid injury, and other complications (7-10).

The present study aims to address these concerns by conducting a comparative analysis of intra- and postoperative parameters of thyroid surgery. We specifically focus on the utilization of two distinct surgical methods: traditional electric knife and straight bipolar electrocoagulation. These surgical techniques have significant implications for patient outcomes, including bleeding risk and nerve injury. However, there remains a need for further investigation and comparison of these approaches to guide clinical practice.

To provide a comprehensive analysis, this study combines a retrospective analysis of patients at our medical center with a meta-analysis of relevant literature. By integrating our own clinical data with existing evidence, we aim to offer valuable insights into the optimal approach for thyroid surgery. We present this article in accordance with the STROBE and PRISMA reporting checklists (available at https://gs.amegroups.com/article/view/10.21037/gs-24-103/rc).

Highlight box

Key findings

- Straight bipolar electrocoagulation forceps reduce operation time, surgical trauma, and complications compared to the traditional electric knife.
- Patients undergoing surgery with straight bipolar electrocoagulation forceps experience faster postoperative recovery.

What is known and what is new?

- Traditional thyroidectomy using an electric knife is associated with higher risks of excessive bleeding and nerve injury.
- The use of straight bipolar electrocoagulation forceps in thyroid surgery shows improved intraoperative and postoperative parameters.

What is the implication, and what should change now?

- Straight bipolar electrocoagulation forceps should be considered as a preferred alternative to the traditional electric knife for thyroid surgery, given its benefits in reducing complications and enhancing recovery.
- Further prospective studies are needed to confirm these findings and refine surgical guidelines for thyroidectomy.

Methods

Patients

Patients were selected for inclusion based on a retrospective analysis of 228 individuals who underwent thyroid surgery for the first time at the Head and Neck Department of Third Affiliated Hospital of Kunming Medical University between January 2014 and November 2018. The inclusion criteria encompassed patients diagnosed with nodular goiter, thyroid adenoma, or thyroid carcinoma (papillary carcinoma), see *Table 1*. This selection aimed to capture a representative sample of diverse thyroid pathologies encountered in clinical practice.

All surgeries were performed by the same surgical team, with same doctor serving as the primary surgeon and all procedures were conducted under the standardized protocols and techniques practiced by our surgical team. The choice between the surgery with traditional electric knife and thyroid surgery involving bipolar electrocoagulation was randomly allocated to patients, ensuring an unbiased selection. Of those patients, 150 underwent traditional electric knife, while the remaining 78 underwent bipolar electrocoagulation.

Informed consent was obtained from all patients prior to surgery. Patients had previously provided written consent for the anonymized use of their medical data for research purposes. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013), and was approved by the ethics committee of the Third Affiliated Hospital of Kunming Medical University (No. KYLX2023-056).

Surgical procedures

Surgical procedures were performed by the same team of clinicians and included various types of thyroidectomies. Preoperative evaluations, including fine needle aspiration cytology and B-ultrasonography, were conducted for suspected thyroid carcinoma cases.

Traditional electric knife surgery utilized an electric knife (model SY-03Y-B, Zhejiang Shuyou, China), while thyroid surgery involving straight bipolar electrocoagulation employed either Peng's multifunctional surgical anatomy device [model SY-VIID (Q)-6, Zhejiang Shuyou, China] or an electrothermal alloy needle-type straight bipolar electrocoagulation forceps (model D5dyx, JNHZ Health Technology, China). Skin incisions were made based on patient age and neck anatomy, and the thyroid gland was dissected using bipolar electrocoagulation forceps.

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Table 1 Clinical data of patients

Characteristic	Traditional (n=150)	Bipolar electrocoagulation (n=78)	P	t/χ^2
Sex				
Male	38 (25.33)	12 (15.38)		
Female	112 (74.67)	66 (84.62)	0.08	2.967
Age, years				
Male	46.38±4.25	50.75±4.18	0.27	1.116
Female	43.76±3.18	45.17±1.52	0.17	1.379
Thyroid disease				
Nodular goiter	15 (10.00)	5 (6.41)		
Thyroid adenoma	27 (18.00)	9 (11.54)		
Thyroid carcinoma (papilla carcinoma)	108 (72.00)	64 (82.05)	0.25	2.798
Type of surgery				
Unilateral thyroid surgery	30 (20.00)	10 (12.82)		
Total thyroidectomy	12 (8.00)	4 (5.13)		
Total thyroidectomy + level VI dissecting	87 (58.00)	49 (62.82)		
Total thyroidectomy + level VI dissecting + unilateral neck dissecting (II–V)	21 (14.00)	15 (19.23)	0.36	3.2

Values are n (%) or mean ± standard deviation, unless otherwise noted.

Hemostasis and tissue dissection were achieved using the electrocoagulation forceps (*Figure 1*).

During surgery, attention was given to preserving the recurrent laryngeal nerve and parathyroid glands. The recurrent laryngeal nerve was carefully exposed and protected during dissection, while the parathyroid glands were identified and preserved *in situ*. The anterior trachea ligament and isthmus were directly cut using bipolar electrocoagulation forceps, and the resection of the unilateral thyroid lobe was completed without sutures.

In cases requiring level VI, meticulous dissection was performed to expose and preserve the recurrent laryngeal nerve and parathyroid glands. Frozen surgical sections were examined by pathology as needed for intraoperative identification of the inferior parathyroid gland.

Data collection and analysis

Data were collected on total operation time, defined from the beginning of skin incision to the end of skin suturing; individual procedure duration, defined as the duration of a single procedure within the overall surgery; intraoperative blood loss; drainage on the first day after operation; hoarseness after operation; and numbness in hands and feet.

Data were analyzed using SPSS 16.0 (IBM, Chicago, IL, USA). Inter-group differences in continuous variables were assessed using Student's *t* test, while differences in categorical variables were assessed using the χ^2 test. Differences associated with $P<0.05$ were considered significant.

Meta-analysis of relevant literature

We performed a systematic search in PubMed (U.S. National Library of Medicine's online database of biomedical articles) and FMRS (Foreign Medical Literature Retrieval Service, China) for studies published between October 2000 and October 2020. Keywords included: "thyroid surgery" and "bipolar". When searching for literature in the FMRS database, Chinese characters for keywords are used. A total of 62 articles were found in the PubMed database, while 79 relevant articles were found in the FMRS database. Two independent authors screened titles and abstracts, followed by full-text reviews to select studies meeting inclusion criteria. Discrepancies were resolved by a third author. Eight studies were included, providing comparative safety outcomes between straight

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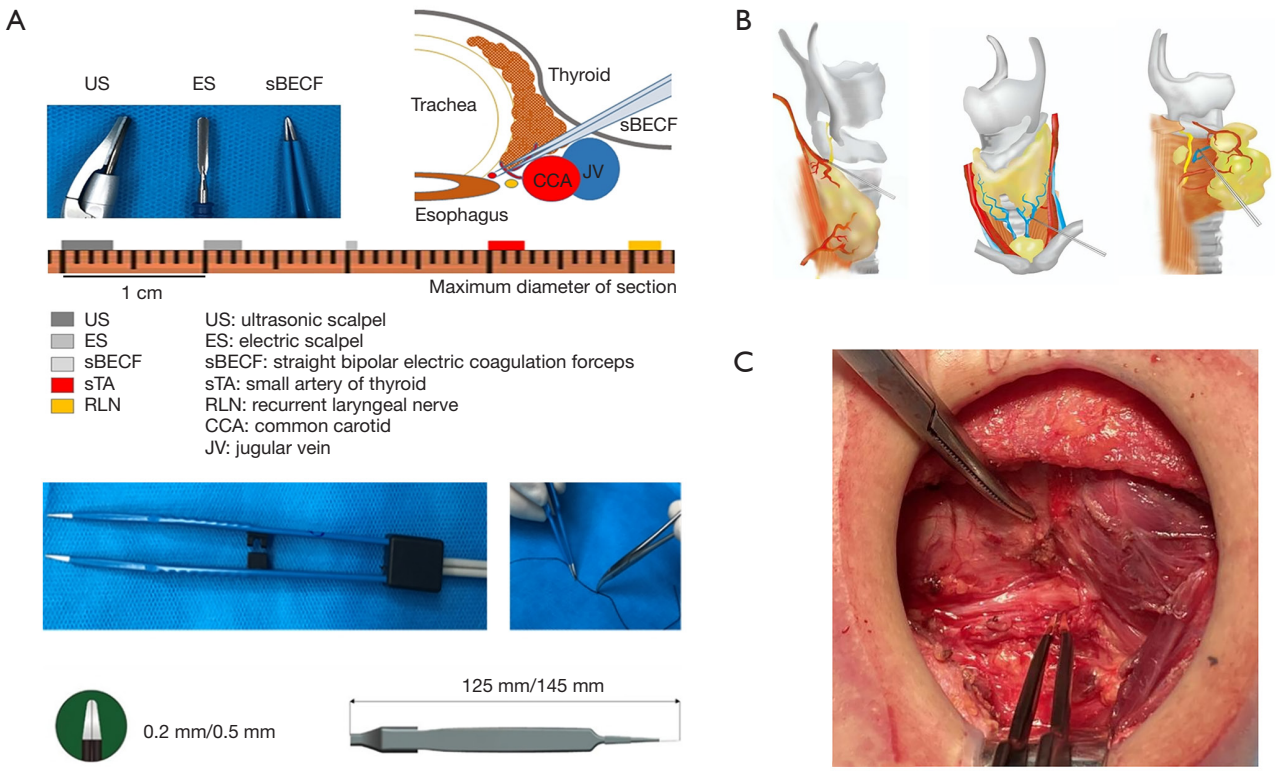

Figure 1 The device and schematic representation of the fine anatomy during thyroid surgery. (A) Illustration showing three devices used for coagulating and severing vessels: US, ES, and sBECF. The sBECF is shown to have a smaller diameter than the sTA or the RLN, with its maximum width being less than 0.5 mm. In contrast, the maximum width of the US is 3.5 mm and that of the ES is 2.5 mm, thereby allowing for finer and more precise manipulations. (B) Detailed schematic of the fine anatomy during thyroid surgery using the sBECF, illustrating the proximity of the sBECF to critical structures such as the RLN and sTA. (C) Intraoperative image depicting the use of sBECF for precise coagulation during thyroid surgery. US, ultrasonic scalpel; ES, electric scalpel; sBECF, straight bipolar electrocoagulation forcep; sTA, small artery of the thyroid; RLN, recurrent laryngeal nerve; CCA, common carotid; JV, jugular vein.

bipolar electrocoagulation forceps and traditional electric knife in thyroid surgery.

Data from eight studies were extracted by two authors using a standardized form. We used "metapack" package (11) in R for statistical analysis, 95% confidence intervals (CIs) were calculated.

Results

Surgical data

Patient data are summarized in *Table 1*. Patients with microcarcinoma without evidence of lymphoid metastasis underwent total thyroidectomy, while all patients with lymph node metastasis in level VI underwent resection of the central area of the thyroid isthmus, except two young patients. Patients with metastatic lymph nodes in lateral cervical regions 2–5 underwent lymph node dissection.

The two types of thyroid surgery were associated with significantly different total and individual procedure duration, intraoperative blood loss and drainage volume on the first day after operation (*Tables 2*,*3*, *Figure 2*).

Complications

Table 4 summarizes all complications clearly attributable to the surgery, which included hoarseness, hypocalcemia, numbness in hands and feet, and convulsions. Since blood was not routinely sampled from all patients, we identified hypocalcemia based on symptoms, rather than on serum levels of Ca^{2+}. The two surgery groups did not differ

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Table 2 Comparison of intra- and postoperative parameters for patients who underwent thyroid surgery involving a traditional electric knife or bipolar electrocoagulation

Group	n	Operation time (min)			Intraoperative blood loss (mL)			Drainage volume on the first day (mL)		
		Mean ± SD	*t*	P	Mean ± SD	*t*	P	Mean ± SD	*t*	P
Unilateral thyroid surgery			7.871	<0.001		6.818	<0.001		1.958	0.057
Bipolar electrocoagulation group	10	31.20±3.26			5.12±3.46			19.30±3.34		
Traditional electric knife group	30	41.10±3.50			20.24±6.68			21.87±3.67		
Total thyroidectomy			6.032	<0.001		8.208	<0.001		2.099	0.054
Bipolar electrocoagulation group	4	42.01±3.46			10.15±3.23			25.25±1.76		
Traditional electric knife group	12	60.38±5.67			30.14±4.45			28.92±3.29		
Total thyroidectomy + level VI neck dissection			23.320	<0.001		22.940	<0.001		2.373	0.02
Bipolar electrocoagulation group	49	56.81±6.78			12.47±5.35			30.14±6.12		
Traditional electric knife group	87	80.35±4.91			40.25±7.46			32.33±4.55		
Total thyroidectomy + level VI neck dissection + unilateral neck dissection (II–V)			18.238	<0.001		11.066	<0.001		4.517	<0.001
Bipolar electrocoagulation group	15	90.35±2.25			30.23±3.56			46.53±8.20		
Traditional electric knife group	21	125.45±7.18			50.38±6.36			63.62±12.88		

SD, standard deviation.

Table 3 The comparison of individual procedure duration of the bipolar electrocoagulation group and traditional electric knife group

Group	Bipolar electrocoagulation	Traditional electric knife	P value	*t*
Unilateral thyroid surgery			<0.001	3.948
Time (min)	10.25±6.16	20.34±7.24		
n	10	30		
Total thyroidectomy			<0.001	16.262
Time (min)	16.25±7.15	35.68±8.25		
n	68	120		
Total thyroidectomy + level VI neck dissection			<0.001	8.238
Time (min)	12.12±5.25	20.68±7.26		
n	64	108		

Values are presented as mean ± standard deviation, unless otherwise noted.

significantly in incidence of hoarseness, but the incidence of hypocalcemia was significantly higher in the traditional electric knife group.

During follow-up of 220 patients during an average of 24 months, no cases of permanent hypocalcemia or permanent recurrent laryngeal nerve paralysis were recorded. Patients with numbness or convulsions of hands and feet were treated with 10% calcium gluconate intravenously, which relieved symptoms within 2 weeks. Patients with temporary hoarseness recovered in 1–3 months after the operation.

Meta-analysis of published data

Our meta-analysis, encompassing data from eight studies

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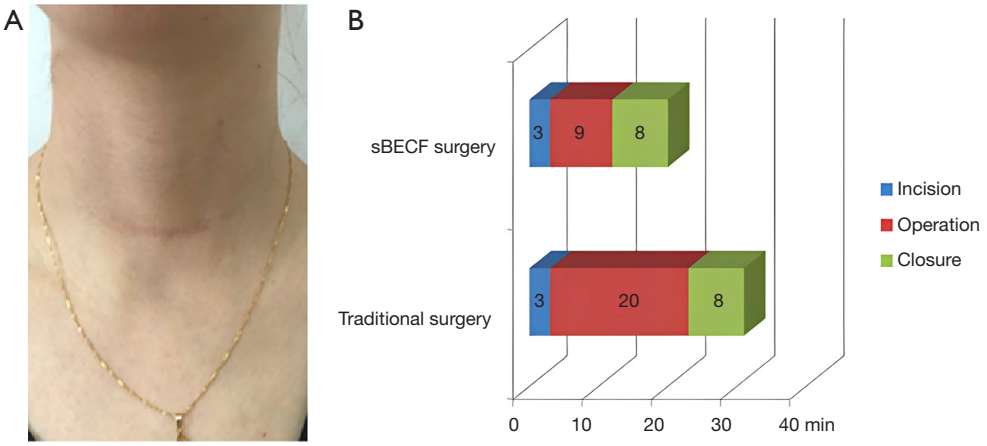

Figure 2 Postoperative scar appearance and duration of surgical phases using sBECF. (A) Postoperative photograph showing the scar of a patient who underwent thyroid surgery using sBECF, demonstrating the minimal scarring associated with this technique. (B) Bar graph illustrating the duration of incision, operation, and closure phases in surgeries performed with sBECF. sBECF, straight bipolar electrocoagulation forcep.

Table 4 Comparison of postoperative complications for patients who underwent thyroid surgery involving a traditional electric knife or bipolar electrocoagulation

Complication	Bipolar electrocoagulation group (n=78)	Traditional electric knife group (n=150)	P value	χ^2
Hoarseness			0.38	0.78
Temporary	3 (3.85)	8 (5.33)		
Permanent	0	1 (0.67)		
Hypocalcemia			<0.001	4.353
Temporary	8 (10.26)	32 (21.33)		
Permanent	0	0		

Values are presented as n (%), unless otherwise noted.

(the process flowchart in the *Figure 3*), corroborates these findings by demonstrating the superiority of bipolar electrocoagulation over the conventional electric knife in thyroid surgery outcomes. Specifically, our analysis involving 989 patients treated with bipolar electrocoagulation and 1,091 patients with the electric knife revealed a statistically significant reduction in total operation time with bipolar electrocoagulation (mean difference =−21.29 min, 95% CI: −26.32 to −16.27; P<0.00001), see *Figure 4*. Moreover, the comparison of intraoperative bleeding volumes between the two techniques, based on data from two studies comprising a total of 266 patients, indicated a significant reduction in bleeding with bipolar electrocoagulation (mean difference =−12.87 mL, 95% CI: −23.81 to −1.93; P=0.02), see *Figure 5*.

Discussion

This retrospective comparison of thyroid surgery involving the traditional electric knife or bipolar electrocoagulation provides evidence that using bipolar electrocoagulation can reduce total operation time by nearly 50% and intraoperative bleeding volume by 80%, without increasing risk of permanent hoarseness or hypocalcemia. The results of our study are consistent with a meta-analysis of eight studies from the literature (12-19). Our findings indicate that bipolar electrocoagulation enables precise surgical maneuvers, potentially resulting in reduced intraoperative bleeding and fewer postoperative complications. This advantage may be particularly beneficial in settings where resources are limited or where surgeons have varying levels

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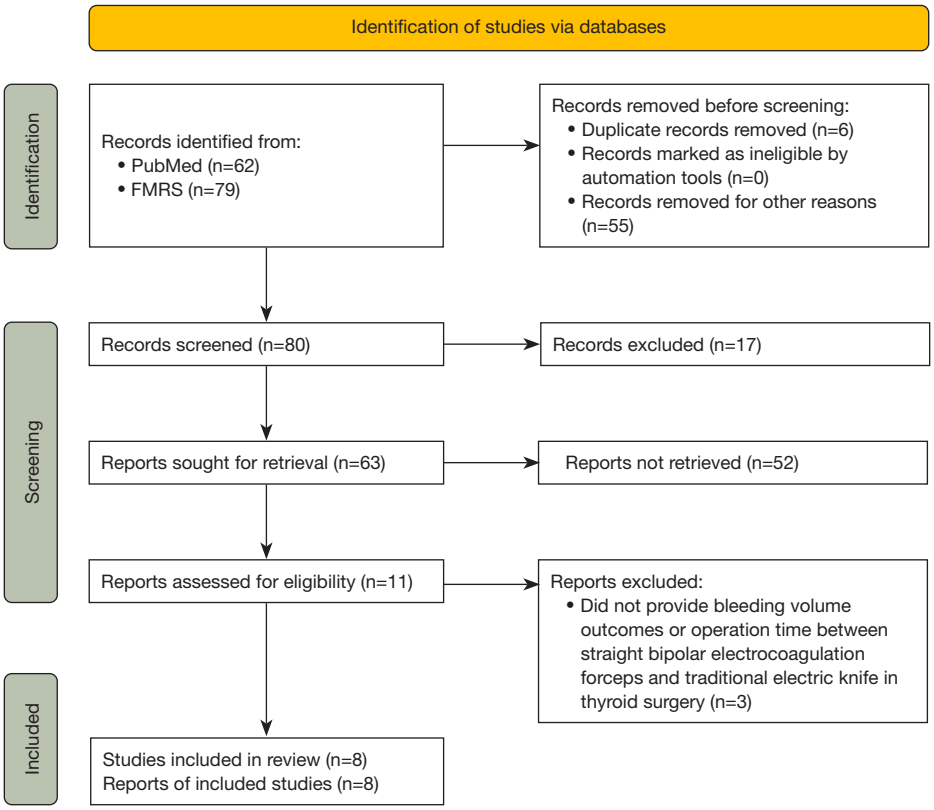

Figure 3 PRISMA 2020 flow diagram for the systematic reviews. The records were excluded manually without the use of automated tools. The selected articles must involve two different types of surgeries, and the procedures of the surgeries must be quite similar to those used in this article. FMRS, Foreign Medical Literature Retrieval Service.

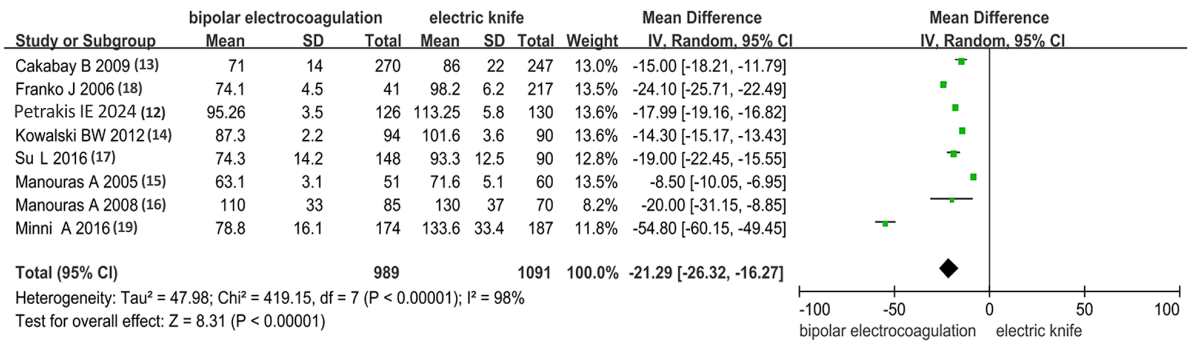

Figure 4 Meta-analysis of total operation time between patients who underwent thyroid surgery involving a traditional electric knife or bipolar electrocoagulation. SD, standard deviation; IV, inverse variance; CI, confidence interval; df, degrees of freedom, I^2, quantifying the degree of heterogeneity.

of experience.

Straight bipolar electrocoagulation forceps dissolve and denature vascular proteins in tissues, combining coagulation and cutting in a single step, making such straight bipolar forceps ideal for fine dissection (17,20,21). These forceps may be superior to ultrasonic and electric knives because they can be operated like pens, reducing artificial jitter, and their working surface is needle-like, allowing micro-

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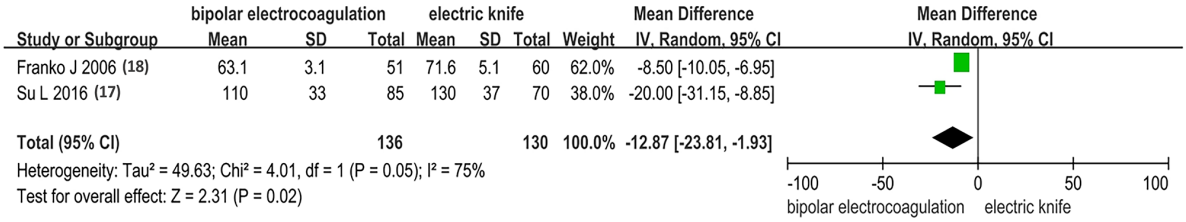

Figure 5 Meta-analysis of intraoperative bleeding volume between patients who underwent thyroid surgery involving a traditional electric knife or bipolar electrocoagulation. SD, standard deviation; IV, inverse variance; CI, confidence interval; df, degrees of freedom, I^2, quantifying the degree of heterogeneity.

hemostasis and micro-cutting without thermal damage to neighboring tissue. These advantages may help explain the ability of such forceps to reduce intraoperative bleeding, which often occurs in traditional electric knife, even with skilled senior surgeons.

Straight bipolar electrocoagulation forceps may also reduce risk of accidental injury to the recurrent laryngeal nerve and parathyroid gland. These tissues can easily be damaged during their dissection on the back of the thyroid gland, because many branches of blood vessels can be treated only by compression and ligation (22). The fine surgical manipulations to protect these tissues are quite challenging with traditional clamp hemostasis and an ultrasonic knife, but our work suggests that the needle-like electrocoagulation forceps can perform the steps smoothly.

In our experience, the straight bipolar electrocoagulation forceps allowed most of the thyroid surgery to be completed with only a small incision, which depends on the minimum diameter of the tumor mass and is generally at least 3.5 cm. The forceps can provide hemostasis without the need to ligate most of the blood vessels. Performing these upper pole manipulations using conventional instruments, in contrast, is difficult and associated with greater risk of damage to high parathyroid glands. To compensate for this, some clinicians leave some upper polar tissue, but this can reduce the efficacy of radioiodine-based cancer treatment after thyroid surgery.

In comparison to conventional surgical instruments, the utilization of straight bipolar electrocoagulation forceps offers distinct advantages, particularly in delicate anatomical regions such as the 'dangerous triangle' of the thyroid capsule. Previous studies have demonstrated that this area, located between the inferior corner of the thyroid cartilage, the lateral wall of the trachea, and the lateral wall of the esophagus, poses a heightened risk of damage to the recurrent laryngeal nerve (22-24). The recurrent laryngeal nerve traverses through this region into the larynx, amidst numerous small blood vessels and adjacent to the Killian-Jamieson area, a vulnerable section of the esophageal wall situated beneath the pharyngeal constrictor muscle and annular pharyngeal muscle (25,26).

The observed advantages of bipolar electrocoagulation in our meta-analysis align with the finer surgical manipulations facilitated by the use of straight bipolar electrocoagulation forceps. These forceps allow for meticulous dissection and coagulation of connective tissue and tiny blood vessels under direct visualization, thereby reducing the risk of damage to the recurrent laryngeal nerve and minimizing intraoperative bleeding. Notably, despite the demonstrated efficacy of bipolar electrocoagulation, the significant heterogeneity among the included studies warrants further investigation to elucidate the underlying factors contributing to the variability in outcomes.

Conclusions

The bipolar electrocoagulation demonstrated significantly shorter total operation time and less intraoperative bleeding compared to the traditional approach. The study findings align with existing literature, suggesting that bipolar electrocoagulation allows for precise surgical maneuvers, potentially reducing bleeding and postoperative complications.

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Footnote

Reporting Checklist: The authors have completed the STROBE and PRISMA reporting checklists. Available at https://gs.amegroups.com/article/view/10.21037/gs-24-103/rc

Data Sharing Statement: Available at https://gs.amegroups.com/article/view/10.21037/gs-24-103/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://gs.amegroups.com/article/view/10.21037/gs-24-103/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013), and was approved by the Ethics Committee of the Third Affiliated Hospital of Kunming Medical University (No. KYLX2023-056). Informed consent was obtained from all patients prior to surgery. Patients had previously provided written consent for the anonymized use of their medical data for research purposes.

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