Original Article

Thyroid surgery outcomes in a 4-year series with intraoperative neuromonitoring: a retrospective cohort study

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Background: Meticulous surgical technique is essential for safe thyroid surgery, with high-volume surgeons experiencing the lowest complication rates. Intraoperative neuromonitoring (IONM) is increasingly adopted in high-volume centers to enhance outcomes and reduce complications. The aim of this study is to evaluate surgery outcomes during IONM introduction in daily practice.

Methods: This retrospective cohort study evaluated morbidity associated with the introduction of IONM by analysing all consecutive thyroid surgeries performed between 2019 and 2022 at Hospital da Luz Lisboa. Patient demographics, clinical characteristics, and surgery-related data were collected. Primary outcomes were recurrent laryngeal nerve (RLN) palsy and annual progression of IONM use. Secondary outcomes included hypoparathyroidism and surgical complications.

Results: A total of 502 patients (98 men and 404 women, with mean ages of 54.9 and 52.6 years, respectively) underwent either lobectomy or total thyroidectomy (TT), involving 719 RLNs at risk (RLNAR). A transient palsy rate of 0.56% and a definitive palsy rate of 0.28% were identified, with no associated risk factors. In the IONM group (n=237), transient RLN palsy occurred in 0.81% of patients, with no definitive palsy cases. IONM use increased from 35.9% in 2019 to 73.2% in 2022 (P<0.001). Permanent hypoparathyroidism occurred in 0.39% of patients. No cervical hematoma or surgical site infection was observed.

Conclusions: The progressive implementation of IONM in thyroid surgery, alongside increasing case complexity and annual surgical volume, may support RLN preservation and reduce morbidity, while enabling gradual skill acquisition. Routine IONM use should be considered to improve patient outcomes, particularly in complex thyroid procedures.

Keywords: Thyroidectomy; intraoperative neuromonitoring (IONM); recurrent laryngeal nerve injury (RLN injury); surgical outcomes; endocrine surgery

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Introduction

A deep understanding of thyroid anatomy and pathology, combined with meticulous surgical technique, is essential in minimizing the risk to the recurrent laryngeal nerve (RLN), the external branch of the superior laryngeal nerve, and the parathyroid glands. Achieving a bloodless surgical field via ligation of tertiary branches of the inferior thyroid artery aids in identifying and preserving these structures (1,2).

Permanent RLN injuries occur in 0.3% to 7% of cases, depending on various factors (3) and visual identification of the RLN has been the gold standard in thyroid surgery for several decades (4). Nevertheless, although nerves may appear morphologically intact, their functional status is unknown to the surgeon unless neural monitoring is performed intraoperatively. Thus, intraoperative neuromonitoring (IONM) is increasingly applied in thyroid and parathyroid surgical procedures, with published recommendations widely adopted in high-volume settings (5-7).

High-volume surgeons perform more total thyroidectomies (TTs), are more likely to operate on oncological patients, perform central compartment dissections (CCDs), and result in shorter hospital stays with lower complication rates (8,9) due to refined surgical techniques.

Highlight box

Key findings

- This study supports the introduction of intraoperative neuromonitoring (IONM) to reduce recurrent laryngeal nerve (RLN) injuries during thyroid surgery. IONM use increased from 35.9% in 2019 to 73.2% in 2022, with transient RLN palsy rates of 0.81% and no cases progressing to definitive paralysis in the IONM-monitored cohort.

What is known and what is new?

- Thyroid surgery carries risks, including RLN injury and hypoparathyroidism. While visual identification of the RLN has traditionally been the standard of care, this study demonstrates that IONM enhances RLN preservation. Its phased implementation reduced RLN injury rates, even with increasing case complexity.

What is the implication, and what should change now?

- The findings support adopting IONM as an important tool in thyroid surgery to improve safety and patient outcomes. Surgeons should consider integrating IONM into routine practice, with training programs focused on its application, to enhance surgical safety and results. This approach can lead to improved preservation of vocal function.

While the use of IONM continues to expand, its efficacy in reducing RLN injury remains debated. Previous studies have shown mixed results, with variations in study design, definitions of RLN injury, and surgical expertise contributing to inconsistent findings (10,11). Moreover, randomized controlled trials are often underpowered due to the low incidence of RLN injury (12), and retrospective analyses frequently lack standardization and blinding. As such, the real-world impact of IONM under consistent surgical conditions is not yet fully understood.

After foundational training in IONM, we began selective usage in 2016, gradually expanding cases as experience grew. This study aims to evaluate the impact of IONM implementation on surgical outcomes over 4 years in a high-volume endocrine surgery unit. We present this article in accordance with the STROBE reporting checklist (available at https://gs.amegroups.com/article/view/10.21037/gs-2025-29/rc).

Methods

Study design and setting

This retrospective cohort study was conducted at the Endocrine Surgery Unit of Hospital da Luz Lisboa and included all consecutive thyroid surgeries performed between January 2019 and December 2022. The study focused on patients who underwent thyroid surgery, either lobectomy or TT, performed by the same experienced endocrine surgeon. The study aimed to compare surgical outcomes between procedures conducted with and without IONM.

Participants

Patients over 18 years old were included if they had undergone thyroid surgery during the specified period and were excluded if they had incomplete clinical records or declined postoperative follow-up. A comprehensive retrospective analysis of clinical records was performed, encompassing all consecutive patients who met the inclusion criteria.

Data collection and variables

Data were collected from digital medical records and pseudo-anonymized 1 to 4 years after surgery. Variables included patient demographics, indications for surgery, surgical volume, number and type of procedures, operative time, histological findings, all complications related to thyroid surgery, pre- and postoperative vocal cord (VC) evaluation, and the annual trend in IONM usage. Surgery length, intraoperative blood loss, hypoparathyroidism, and other postoperative morbidities were also recorded.

Ethical considerations

Approval was obtained from the Ethics Committee of Hospital da Luz Lisboa (Ref. CES/36/2023/JAG). The study was conducted in accordance with the Declaration of Helsinki and its subsequent amendments. Patient confidentiality was maintained per Portuguese and European regulations. Requirement for informed consent was waived due to the retrospective nature of the study. Each patient received a serial code that was subsequently assigned, and only the lead investigator could correlate the patients' identities with the code.

Perioperative management

All patients were brought to an euthyroid state during the preoperative period. Surgery was recommended following informed consent and based on a multidisciplinary team decision when necessary.

Before surgery, all patients underwent evaluation by an otolaryngologist [ear, nose, and throat (ENT)] consultant, including laryngoscopy, to check for any VC palsy, even when no symptoms were reported. However, between March 13, 2020, and July 29, 2021, due to restrictions imposed by the coronavirus disease 2019 (COVID-19) pandemic, only patients with vocal complaints were evaluated before surgery. Status was categorized as having normal mobility, hypomobility or paralysis on the right or left side.

Postoperative ENT formal evaluation by laryngoscopy was performed in all patients who revealed any slight vocal tone alteration, 1 month after surgery. Follow-up laryngoscopic evaluations were routinely performed at 3, 6, and 12 months, according to institutional protocol.

Surgical procedure

All thyroid surgeries were performed using a meticulous, sharp capsular dissection, loop 2.5× magnification, and frontal headlight, and the ultrasonic device Harmonic FOCUS® (Ethicon Inc., Cincinnati, OH, USA) was used in all cases to achieve a bloodless surgical field.

All patients who underwent TT, regardless of whether they had cervical node dissection or completion thyroidectomy (CT), received supplementation with calcium and cholecalciferol starting from the day 1 after surgery. This supplementation aimed to prevent any transient hypocalcemia. The surgeon adjusted the supplementation dosage during postoperative week 1, at 1 and 3 months, as deemed necessary. When IONM was used, evaluations followed the International Neural Monitoring Study Group guidelines using the Nerve Integrity Monitor (NIM 3.0) System (Medtronic Xomed, Jacksonville, FL, USA).

Outcomes to be measured

Primary outcomes

The first primary outcome was the incidence of postoperative RLN injury, defined as paresis confirmed by laryngoscopy no later than 1 month postoperatively when injury was suspected due to symptoms (dysphonia) or loss of signal during IONM. It was considered permanent if total recovery was not observed on laryngoscopy within 12 months of surgery. IONM loss of signal was defined as a vagus nerve signal <100 µV at the end of surgery. The second primary outcome was the annual progression in number of patients who underwent surgery with IONM.

Secondary outcomes

To evaluate the quality of surgery, various parameters were quantified, despite the use of IONM, including intra and postoperative blood loss, surgical length (from skin incision to closure), postoperative length of stay, hematoma and seroma (even if surgical drainage was not required), surgical site infection until postoperative day 30 and definitive hypoparathyroidism, defined as albumin corrected serum calcium <8 mg/dL more than 6 months post-surgery, requiring calcium or vitamin D supplementation, with parathyroid hormone (PTH) value <15 pg/mL.

Statistical analysis

The qualitative variables were presented as frequencies and proportions. Fisher's exact test was used to compare qualitative variables. The quantitative variables are presented as the mean ± standard deviation (SD). The normal distribution of quantitative variables was assessed with the Shapiro-Wilk test, and the equality of variances was assessed with Levene's test. For quantitative variables,

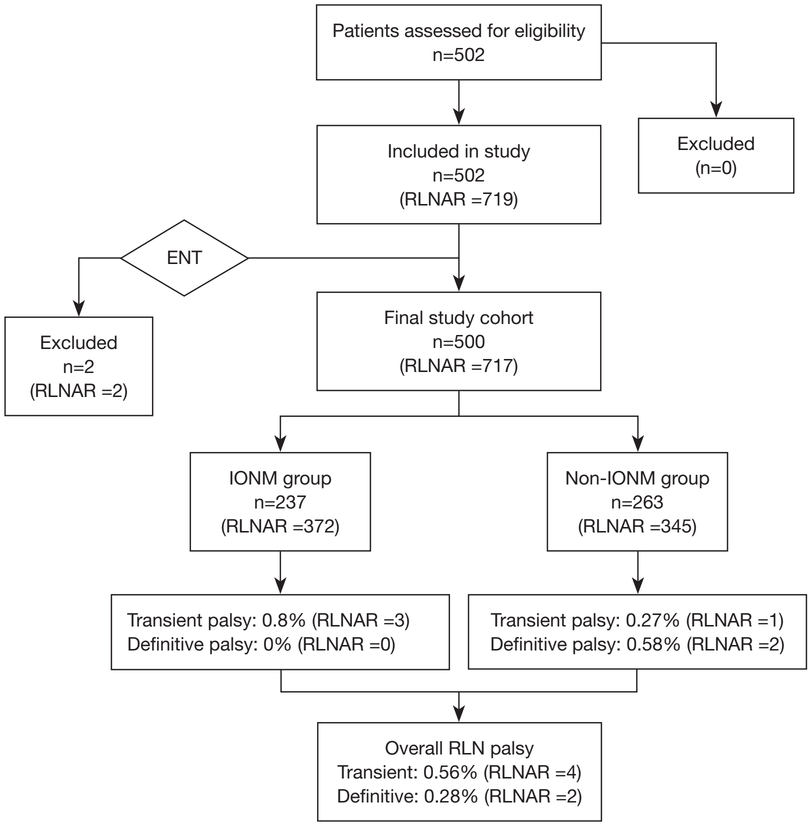

Figure 1 Flow diagram summarizing the study's patient flow and key outcomes, including the distribution between the IONM and non-IONM groups and their respective RLN palsy rates. ENT: preoperative RLN paralysis confirmed at otolaryngologist performed laryngoscopy. ENT, ear, nose, and throat; IONM, Intraoperative neuromonitoring; RLNAR, recurrent laryngeal nerves at risk.

unpaired Student's *t*-test or the Mann-Whitney *U* test was used when applicable for bivariate analysis.

Univariate and multivariate logistic regression models were constructed and adjusted for confounding variables. The goodness of fit for the regression equation was assessed using the Hosmer-Lemeshow test. The model's correct classification percentage was also calculated. In all cases, models were constructed by considering the parsimony principle, including a limited number of variables but always including the leading independent and relevant variables. Statistical significance was set at two-sided P< 0.05.

Results

Patient characteristics

Between 2019 and 2022, a total of 502 patients (98 men and 404 women) underwent 719 RLN dissections. The overall mean ± SD age was 53.1±14.6 years, with male patients averaging 54.87±14.97 years and female patients averaging 52.58±14.57 years. Annual case numbers were as follows: 113 patients in 2019 [156 RLNs at risk (RLNAR)], 106 in 2020 (160 RLNAR), 140 i1-2n 2021 (198 RLNAR), and 143 in 2022 (205 RLNAR).

A flow diagram illustrating patient inclusion, group distribution, and key outcomes is presented to provide a visual summary of the study's design and results (see *Figure 1*).

Pathological examination revealed 334 benign cases and 168 malignant cases. Regarding the surgical procedures performed, lobectomies accounted for 56.8% of the cases, while TTs (with or without cervical dissections) comprised 43.2%. The distribution of patients by surgery type and the corresponding number of RLN dissections are detailed in *Table 1*.

Primary outcomes

Postoperative vocal complications: among the 502 patients, 380 underwent preoperative laryngoscopy (122 were not

Table 1 Distribution of patients by type of surgery and the number of RLNAR dissected

Type of surgery	Frequency, n	Percentage (%)	RLNAR, n
Lobectomy	285	56.77	285
TT	167	33.27	334
TT with CCD	40	7.97	80
TT with CLCD	10	1.99	20
Total	502	100	719

Lobectomy: unilateral lobectomies or CTs. CCD, central compartment dissection; CLCD, central and lateral compartment dissection; CT, completion thyroidectomy; RLNAR, recurrent laryngeal nerves at risk; TT, total thyroidectomy.

evaluated due to COVID-19), revealing 13 patients (3.42%) with preexisting VC dysmotility. Of these, 10 showed hypomotility without paresis of one VC. Postoperative laryngoscopy demonstrated no change in six patients, while four returned to normal. Two patients had a preoperative paretic VC on the surgical side (both with benign cytology); in these cases, IONM had not detected a vagus signal before dissection, and a 1-month follow-up confirmed persistent paralysis.

Additionally, one patient exhibited a paretic vocal fold on the contralateral (right) side due to a previous procedure. During surgery for a left plunging goiter requiring sternotomy, anatomical preservation was achieved; however, the left RLN signal decreased by more than 50% during IONM, and the vagus signal fell below 100 mV. Consequently, a temporary tracheostomy was performed due to bilateral RLN paresis. Laryngoscopy at 2 months confirmed complete recovery of left RLN function.

Among the 367 patients with normal VC motility on preoperative laryngoscopy, six reported dysphonia 1 week after surgery. At 1 month, four patients continued to experience dysphonia and were evaluated by an ENT consultant. Of these, two recovered normal VC function, three were found to have hypomotility (with one recovering completely at 3 months and two progressing to complete, definitive paralysis at 6 and 12 months), and 1 patient with confirmed unilateral paresis at 1 month showed partial recovery at 3 months before fully recovering at 10 months.

Among the 361 patients without dysphonia during the first postoperative week, four reported some vocal alterations at 1 month, although laryngoscopy at that time revealed no abnormalities. Additionally, of the 357 patients who did not report any vocal complaints, 64 underwent laryngoscopy 1 month after surgery—either due to slight changes in voice tone or as a preoperative measure before completion of thyroidectomy—and only one case of hypomotility was identified, with the patient experiencing complete recovery by the 6-month follow-up.

For the 122 patients not evaluated with preoperative laryngoscopy, none reported voice alterations (IONM was used in 41 of these cases).

Excluding the two patients, with benign cytology, who had preexisting RLN paralysis before homolateral lobectomy, the overall transient RLN palsy rate was 0.56% and the definitive palsy rate was 0.28% (see *Tables 2,3*).

Due to the limited number of RLN injuries and heterogeneity within groups, no further analyses were conducted to assess associations with potential risk factors (such as age, preoperative diagnosis, tumor size, type of procedure, surgical duration, blood loss, IONM use, or final pathology).

However, as shown in *Table 4*, among the 237 patients who underwent surgery with IONM (accounting for 372 RLN dissections, 52.1% of the total RLNAR), only 3 patients (0.81%) experienced transient RLN palsy, and none progressed to definitive palsy. Furthermore, when evaluating patients with benign (330 patients/461 RLNAR) or malignant (170 patients/256 RLNAR) final histology—regardless of IONM use—the incidences of transient and definitive RLN palsy were 0.43% and 0.22% for benign cases, and 0.78% and 0.39% for malignant cases, respectively.

In summary, global transient RLN palsy occurred in 0.56% and definitive palsy in 0.28% of all RLNAR. Among patients monitored with IONM (n=237), 0.81% experienced transient palsy, with no cases of definitive palsy observed (see *Figure 1*).

Annual progression of patients selected for surgery with IONM

Over this 4-year period, IONM use increased steadily. In 2019, 37 surgeries were performed with IONM, followed by 40 in 2020, 63 in 2021, and 99 in 2022, totaling 239 patients (including two patients with preoperative RLN palsies). This upward trend is illustrated in *Figure 2*, which shows the annual number of patients operated on, while *Table 5* provides a summary of the RLNAR dissections performed with and without IONM. Overall, IONM adoption rose from 35.9% in 2019 to 73.2% in 2022 (P<0.001), and its use was associated with a reduction in RLN injury.

Table 2 Definitive RLN palsy cases and their characteristics

Serial	Date	Gender	Age (years)	Cytology	Size (mm)	Surgery				Recovery (month)		
						Procedure	Blood (mL)	IONM	Pathology	1	6	12
22	Mar 2019	Female	49	Malignant	<20	Lobectomy	5	No	PTC pT1a N0a	Hypomobility	Paralysis	Paralysis†
41	May 2019	Female	45	FLUS	<60	Lobectomy	20	No	Adenoma	Hypomobility	Paralysis	Paralysis‡

Size: size of the nodule that prompted surgery; blood: intraoperative blood volume lost. †, no dysphonia, no limitation at work, laryngoscopy with complete contralateral compensation; ‡, no dysphonia, uses microphone to lecture in auditorium, laryngoscopy with complete contralateral compensation. FLUS, follicular lesion of undetermined significance; IONM, intraoperative neuromonitoring; PTC, papillary thyroid carcinoma.

Table 3 Transient RLN palsy cases and their characteristics

Serial	Date	Gender	Age (years)	Cytology	Size (mm)	Surgery				Recovery (month)				
						Procedure	Blood (mL)	IONM	Pathology	1	2	3	6	10
14	Feb 2019	Female	49	Malignant	<20	Lobectomy	5	Yes†	PTC pT1aN0b	Paresis		Hypomobility		Completely recovered
50	Jun 2019	Female	48	Malignant	<20	TT CLCD	10	No	PTC pT1bN1b		Hypomobility			Completely recovered
275	Jun 2021	Female	81	Benign	Plunging goiter	Completion TT	10	Yes‡	Nodular hyperplasia	Paresis	Hypomobility			Completely recovered§
363	Jan 2022	Female	50	Benign	Multinodular goiter	TT	10	Yes¶	Nodular hyperplasia		Hypomobility			Completely recovered

Blood: intraoperative blood volume lost. †, mechanical injury well identified 5 mm to laryngeal entrance during hemostasis; ‡, RLN anatomically preserved, no evidence of structural or thermal injury (with long sensitive bifurcation), IONM RLN signal reduced over 50% and vagus signal under 100 mV, tracheostomy performed due to contralateral previous RLN paralysis; §, temporary tracheostomy taken down; ¶, normal IONM vagus nerve values after dissection on both sides. CLCD, central and lateral compartment dissection; IONM, intraoperative neuromonitoring; PTC, papillary thyroid carcinoma; RLN, recurrent laryngeal nerve; TT, total thyroidectomy.

Table 4 Number of RLNAR and incidence of transient and definitive RLN injury, considering histology and IONM usage

Global	RLNAR, n	RLN lesion			
		Transient		Definitive	
		N (%)	P	N (%)	P
Histology	717	4 (0.56)	0.55	2 (0.28)	0.67
Benign	461	2 (0.43)		1 (0.22)	
Malignant	256	2 (0.78)		1 (0.39)	
IONM			0.35		0.14
Without	345	1 (0.29)		2 (0.58)	
With	372	3 (0.81)		0 (0.00)	

The significance level was set at two-sided P<0.05. IONM, intraoperative neuromonitoring; RLN, recurrent laryngeal nerve; RLNAR, recurrent laryngeal nerves at risk.

Table 5 Number of patients who underwent surgery per year, with and without IONM and corresponding RLNAR

Year	Total		Without IONM			With IONM			P†
	Patients, n	RLNAR, n	Patients, n	RLNAR, n	%	Patients, n	RLNAR, n	%	
2019	113	156	76	100	64.1	37	56	35.9	–
2020	106	160	66	94	58.8	40	66	41.2	0.44
2021	140	198	77	96	48.5	63	102	51.5	0.25
2022	143	205	44	55	26.8	99	150	73.2	<0.001
Total	502	719	263	345	48.0	239	374	52.0	–

†, comparison of the annual proportion of patients who underwent IONM with that of the first year [2019], the significance level was set at two-sided P<0.05. IONM, intraoperative neuromonitoring; RLNAR, recurrent laryngeal nerves at risk.

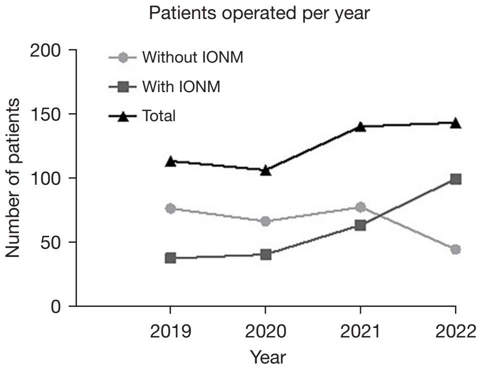

Figure 2 Global number of patients who underwent surgery per year, with and without IONM. IONM, intraoperative neuromonitoring.

Secondary outcomes

As secondary outcome, we compared the length of surgery for procedures performed with *vs.* without IONM, categorized by type of surgery. A statistically significant increase in operative time was observed in surgeries where IONM was used (see *Table 6*).

Intraoperative and postoperative blood loss was minimal (as shown in *Table 7*), and most patients had a hospital stay of less than 48 hours, regardless of the surgical procedure. The exception was for patients undergoing TT with central and lateral compartment dissection (CLCD), among whom 6 patients required a longer admission.

No cervical hematomas developed, and no postoperative

Table 6 Length of surgery, with and without IONM, for each type of surgery

Type of surgery	Length of surgery (min)										*U*	P value
	With IONM					Without IONM						
	N	Mean ± SD	Median (IQR)	Test	P value	N	Mean ± SD	Median (IQR)	Test	P value		
Lobectomy or CT	105	70.8±34.1	62.0 (20.0)	KS	<0.001	180	61.5±17.6	58.5 (18.3)	KS	<0.001	11,320.5	0.005
TT	106	113.3±36.4	106.0 (40.8)	KS	<0.001	61	92.2±23.1	92.0 (30.0)	KS	0.20	4,413.5	<0.001
TT with CCD	21	132.2±78.5	94.0 (74.0)	SW	<0.001	19	86.0±18.3	83.0 (16.0)	SW	0.18	289.5	0.01
TT with CLCD	7	270.9±80.8	271.0 (160.0)	–	–	3	202.7±86.5	201.0 (0.0)	–	–	15.0	0.38

The significance level was set at two-sided P<0.05. CCD, central compartment dissection; CLCD, central and lateral compartment dissection; CT, completion thyroidectomy; IONM, intraoperative neuromonitoring; IQR, interquartile range; KS, Kolmogorov-Smirnov test; SD, standard deviation; SW, Shapiro-Wilk test; TT, total thyroidectomy; *U*, Mann-Whitney *U* test.

Table 7 Mean operative blood loss, postoperative blood loss, and length of stay by type of surgery

Type of surgery	Number	Operative blood loss (mL)		Post operative blood loss (mL)		Length of hospital stay <48 h (%)
		Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	
Lobectomy or CT	285	11.8±46.9	10.0 (5.0)	18.2±16.1	15.0 (17.0)	96.8
TT	167	21.2±60.6	10.0 (15.0)	30.0±28.9	25.0 (28.0)	85.6
TT with CCD	40	11.3±12.0	9.0 (5.0)	11.3±12.0	9.0 (5.0)	82.5
TT with CLCD	10	25.7±18.15	20.0 (40.0)	84.3±56.8	60.0 (108.3)	40.0
Total	502	–	–	–	–	–

CCD, central compartment dissection; CLCD, central and lateral compartment dissection; CT, completion thyroidectomy; IQR, interquartile range; TT, total thyroidectomy; SD, standard deviation.

mortality was recorded. Minor seromas occurred in only 1.59% of cases (five plunging goiters, two lobectomies, and one TT with CCD), which resolved without drainage.

Additionally, temporary postoperative calcium and/or vitamin D supplementation was required in 14.9% of TT or CT patients (n=255), with permanent hypoparathyroidism observed in only 1 patient (0.39%).

In summary, the mean operative time increased significantly with IONM use across all surgical types (P<0.05), permanent hypoparathyroidism occurred in 0.39% of cases, and no cases of cervical hematoma or surgical site infection were reported.

Discussion

Advancements in thyroid surgery, such as dedicated endocrine surgeons, new surgical devices, loop magnification, and IONM, have significantly reduced morbidity. Recent clinical guidelines emphasize referring patients with thyroid pathology to specialized endocrine centers to reduce complications and morbidity (9,13-15).

To mitigate biases related to surgical technique and patient selection, all 719 RLN dissections in this study were performed consecutively by an experienced general surgeon specializing in neck endocrine surgery with 15 years of experience. Preoperative VC evaluation is particularly important in cases of thyroid malignancy (16). In our series, only a small percentage of patients (7 out of 380; 1.84%) reporting preoperative hoarseness were demonstrated with preoperative VC issues at ENT evaluation. Conversely, among the 380 patients who underwent preoperative evaluation (as 122 were not evaluated due to the COVID-19 pandemic), 13 (3.42%) exhibited some degree of vocal fold dysmotility, and 6 of these patients did not report hoarseness. Recognizing preexisting VC paralysis or hypomobility is essential for accurately interpreting IONM nerve conductivity values, as risk assessment remains a crucial aspect of patient care, particularly in asymptomatic individuals (17).

Postoperative ENT evaluations were conducted with a low threshold for clinical assessment, since insurance policies typically do not cover these evaluations unless vocal complaints are present. Although not all patients underwent postoperative evaluation—a limitation of the study—any subtle changes in vocal tone prompted a formal laryngoscopy until 1 month after surgery, with further assessments performed if necessary, by the same ENT specialist.

In cases of multinodular goiter associated with preoperative VC paralysis, some recovery can be observed (18). In our series, 10 out of 380 patients exhibited hypomotility without paresis on preoperative laryngoscopy. None of these patients reported post-surgery voice alterations, and four showed improvement to normal motility on laryngoscopy. Preserving any preoperatively affected RLN during surgery is thus crucial, particularly when IONM indicates conductivity.

The incidence of transient and permanent RLN palsy in our overall and IONM-monitored patient cohorts was consistently low (8,19). Even when analyzing patients with benign and malignant conditions separately (regardless of IONM use), the frequencies of both transient and permanent RLN palsy remained below 1%. These outcomes are consistent with published data and a meta-analysis of RLN injuries, reporting transient and permanent VC paralysis rates of 9.8% (range, 1.4–38.4%) and 2.3% (range, 0–18.6%), respectively (20).

Several studies (21,22) have identified risk factors for VC paralysis and functional outcomes after thyroidectomy—including thyroid volume, malignancy, reoperation, lymph node dissection, and recurrent thyroid malignancy. However, our study could not identify any individual variable as an independent risk factor, due to the limited number of RLN lesions available for subgroup analysis and statistical validation.

It has been described that IONM has a learning curve that improves after approximately 50 cases (23,24), and we began occasionally using IONM in 2016, surpassing 50 sporadic cases by 2018. The annual number of RLN dissections in this study increased from 156 in 2019 to 203 in 2022, with a significant rise in the proportion of patients undergoing IONM (P<0.001), accompanied by a decrease in the incidence of RLN lesions. Notably, the two definitive RLN palsies and two of the four transient palsies occurred in 2019, the last one being exactly the 50^{th} consecutive case in the series (see *Tables 2,3*). The remaining two transient cases were recorded in 2021 and 2022, both involving IONM.

Thus, while intermittent IONM cannot completely prevent RLN lesions due to various potential injury mechanisms, it appears to reduce RLN injury rates and assists in nerve identification, as demonstrated in a recent European multicentric study (9).

Although a recent meta-analysis (10) found comparable operative times between IONM and visual nerve monitoring alone, our "real-life" series of 502 consecutive cases revealed that unilateral lobectomies and TT with or without CCD took significantly longer when IONM was used (P<0.05), possibly reflecting case increasing complexity. Yet, a mean difference of 9 minutes for a lobectomy (70.8±34.1 *vs.* 61.5±17.6) and 24 minutes for a TT (113.3±36.4 *vs.* 92.2±23.1) might not be clinically significant compared to the potential benefit. For TT with CLCD (P=0.38), we found no significant difference in operative length.

While seroma is considered a minor complication, it is aesthetically undesirable and may resolve slowly without percutaneous drainage (25). In our series, seroma was observed in only 1.59% of patients, with the systematic use of a closed suction drain for less than 24 hours and no infections.

Regarding hypoparathyroidism, no cases of postoperative hypocalcemia were reported as all patients undergoing TT or CT received calcium and/or vitamin D supplementation, which facilitated the shortest possible hospital stay (26). Only 4 patients (1.57%) experienced transient hypoparathyroidism, discontinuing supplementation at 4 weeks post-surgery, while 1 patient (0.39%) developed permanent hypoparathyroidism—rates that are in line with the lowest reported in the literature (transient: 1.0%–58.0%; permanent: 0–29.2%) (27-29).

Despite our findings, we acknowledge certain methodological limitations inherent to our study design. As a retrospective analysis, it is susceptible to bias. However, all clinical data were prospectively recorded at the point of care using standardized electronic forms, enhancing data accuracy and consistency. Data collection, performed one to 4 years postoperatively by different authors, used pseudo-anonymized records—introducing an intrinsic blinding effect that likely minimized outcome assessment bias. To further reduce bias, patients with preoperative RLN paralysis and incomplete records were excluded. Additionally, potential confounding factors—such as age, preoperative diagnosis, thyroid volume, presence of thyroiditis, tumor size, type of procedure, surgical duration, and blood loss—were not found to significantly impact outcomes, likely due to the low incidence of RLN injuries in our cohort.

All procedures were performed by a single experienced endocrine surgeon at a high-volume center, reducing variability in surgical technique. While this context strengthens internal validity, it may limit generalizability to lower-volume settings. Nonetheless, the benefits of IONM could be even more substantial in such contexts, particularly when supported by appropriate training.

We also recognize that a formal cost-effectiveness analysis was not included, as it would require a dedicated study design and long-term follow-up, which were beyond the scope of this study.

Overall, our findings offer real-world insight into the progressive adoption of IONM in thyroid surgery. The results support its potential to reduce RLN injury without increasing surgical morbidity and align with current international guidelines recommending its use in high-risk procedures. Future prospective studies are warranted to validate the anatomical landmarks described and to assess the long-term outcomes associated with IONM.

Conclusions

Morbidity in thyroid surgery is nearly nonexistent when performed by experienced endocrine surgeons; however, these surgeons often handle the most challenging cases. While permanent hypoparathyroidism may have a greater impact on quality of life than unilateral VC palsy, preserving RLN function remains a primary concern. Several technical and visual adjuncts exist to minimize the risk of RLN injury, yet surgical skill and training are paramount, as visual identification of the RLNAR, eventually aided by IONM, continues to be the gold standard for achieving minimal vocal morbidity.

Although with limited statistical power, our series recognizes the implementation of IONM in thyroid surgery may enhance RLN preservation and reduce morbidity. Routine use of IONM should be considered to improve patient outcomes, particularly in complex thyroid procedures.

To ensure accurate identification and preservation of the RLN, all established anatomical landmarks—tracheoesophageal groove, relationship with the inferior thyroid artery, Zuckerkandl tubercle, the superior parathyroid, and Berrys' ligament (30) were systematically identified during surgery, with strict use of loupe magnification and bloodless capsular dissection. Over these 4 years, 719 RLN dissections with increasing use of IONM have allowed us to refine our surgical technique and even suggest a potential new visual landmark for RLN identification. If validated, this additional anatomical reference could further improve thyroid surgery outcomes. This concept is currently being explored in a prospective study.

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Footnote

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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. Approval was obtained from the Ethics Committee of Hospital da Luz Lisboa (Ref. CES/36/2023/JAG). The study was conducted in accordance with the Declaration of Helsinki and its subsequent amendments. Patient confidentiality was maintained per Portuguese and European regulations. Requirement for informed consent was waived due to the retrospective nature of the study.

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