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*Article*

# Recovery of Vocal Cord Function After Thyroid Surgery Often Takes Months with Loss of Signal During IONM as an Independent Predictor of Prolonged Recovery

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## Abstract

**Background:** Post-thyroidectomy vocal cord dysfunction (PT-VCD) is an important side effect of thyroid surgery. With the introduction of IONM, hopes have been raised that either the rate or severity of PT-VCD could be reduced. However, data to support these concepts are scarce. To better understand the relationship between IONM outcomes and the severity of PT-VCD, a detailed time course evaluation of recovery of PT-VCD was performed in a continuous clinical quality registry from a specialized high-volume endocrine surgery center. **Methods** Retrospective analysis of prospectively documented data from a clinical quality assurance registry from June 2015 to May 2016 with a 12-month follow-up of all cases. All patients underwent vocal cord (VC) laryngoscopy (VCL) by independent ENT specialists before and after surgery. Cases with newly diagnosed PT-VCD were enrolled in a detailed follow-up program (recruiting from June 2015 to May 2016) and structured telephone interviews every 4-6weeks to assess the exact time course of PT-VCD recovery and VC status for periods of at least 12 months. Clinical data were analyzed for variables affecting the time course of recovery by univariate analysis. **Results** From 6/2015 - 5/2016 there were 1097 consecutive thyroid procedures. During this period, there were 78 PT-VCD (1591 nerves at risk (NAR); 4,9 %) entered into the detailed follow-up-program. Of these, 3 PT-VCD persisted at 12 months (PT-VCD 0,18 % NAR), with 6 LOF (maximum rate of potentially persisting PT-VCD of 0,54% NAR). 15% of PT-VCD recovered within 4 weeks, mean recovery time was 4.4 months and 6 months after thyroidectomy 18 % still had impaired VC laryngoscopy tests. Individual cases were followed > 12 months showing late full recovery of PT-VCD, challenging the definition of permanent VCD. Logistic regression analysis revealed non-transitory loss of signal (ntLOS) (OR for recovery within 12 weeks 0.39 (95%CI 0.15-0.98), p= 0.046) and more specific, secondary ntLOS to be a significant independent predictor of PT-VCP recovery > 12 weeks (OR for recovery within 12 weeks 0.303 (95%CI 0.115-0.797), p= 0.016). **Conclusion:** For the first time, these data provide a detailed description of the time course of PT-VCD recovery in a large cohort and a correlation with operative data and IONM. We found that recovery takes a long time and non-transitory loss of signal – especially secondary ntLOS - during IONM was associated with prolonged PT-VCD recovery. Therefore, IONM provides an additional benefit and early initiation of speech therapy may be advisable for these patients.

**Keywords:** thyroid surgery; vocal cord palsy; vocal cord dysfunction; time-course analysis; intraoperative neuromonitoring recurrent laryngeal nerve

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## Introduction

Initiation of speech-therapy for post thyroidectomy (PT) vocal cord dysfunction (VCD) would benefit from a better understanding of VCD recovery. However, such data is currently not available. Therefore, we obtained a detailed time course analysis of PT-VCD from a continuous clinical quality registry.

Vocal cord dysfunction after thyroidectomy is a feared surgical complication. It is well known, that its clinical course can be very different. To provide transparent and comparable quality data vocal cord-tests by direct laryngoscopy by an independent ENT-specialist are essential after every thyroid surgery.

In the last three decades surgical extent changed from subtotal to more radical procedures (lobectomy, total or nearly-total thyroidectomy) to prevent risky re-do operations in recurrent goiters. It became gold standard to identify and visualize the recurrent laryngeal nerve in subtile preparation and that could decrease permanent vocal cord palsies due to recurrent laryngeal nerve (RLN) injury. Although the role of intraoperative laryngeal nerve monitoring (IONM) could not show reduction of unilateral RLN injury, it could demonstrate its benefit in preventing patients from dreaded bilateral vocal cord palsy.

Literature reveals many studies about incidence of VCD and risk factors for RLN injury in thyroid surgery. But, to our knowledge, there are no known clinical markers to predict the time course or risk factors indicating a late recovery of VCD. Often, there is no evident intraoperative reason for the nerves' damage and in most cases the RLN keeps its macroscopic integrity. Guided by that impression, surgeons tend to expect a fast recovery. Usually, speech therapy or any other special therapeutic options are postponed until protracted clinical course is observable many weeks after surgery. In this time period, patients suffer from reduced voice quality and, depending on profession, often from inability to work. Contrary to general expectations, experiences from our follow-up data since 2015 frequently showed a more prolonged recovery, lasting often a few months.

Nowadays, more extensive preparation of the RLN and often use of IONM is surgical standard and we assume that such intraoperative findings could help to understand more about the type of nerve damage and its recovery. This leads us to the current work, which aimed to analyze the time course of a VCD by using our follow-up data and looking for differences in intraoperative neuromonitoring findings and clinicopathological markers. Predicting the expected course of a VCD recovery could help surgeons to change clinical strategies in supporting patients with postoperative VCD and to apply individualized therapeutic procedures to our patients.

*Study Population*

This is a retrospective analysis of prospectively documented data of a consecutive 12-month series of patients undergoing thyroid surgeries at a specialized center of Endocrine Surgery. Datasets of the registry, medical charts as well as data from the Centers' structured follow-up program were analyzed including an unselected continuous series of patients undergoing thyroid surgeries in this institution between June 2015 and May 2016. Only patients with preexisting unilateral or bilateral VCD were excluded from this analysis. With regard to the datasets until discharge of an individual patient, there were no missing values.

*Application of IONM and Definition of "Loss of Signal" LOS [1]*

Application of intraoperative neuromonitoring (IONM) - the nomenclature is based on the recommendations of the International Neural Monitoring Study Group (INMSG) [2], including the recommended standards for loss of signal evaluation/intraoperative problem-solving algorithm [3]. In **primary LOS**, no VC-EMG (Vocal cord EMG) is obtained during surgery despite extensive efforts, including changing equipment. This means that, despite all attempts to acquire a usable EMG signal, no signal is detected. In **secondary LOS**, a VC-EMG is initially obtained at the vagal nerve, but the

 doi:10.20944/preprints202603.0516.v1



EMG signal is lost during the course of the surgery. The loss is documented as either remaining absent (non-transitory LOS: ntLOS) or recovering (transitory LOS).

*Perioperative and Procedural Data*

All individuals in this series underwent surgery at a high-volume centre of reference in thyroid and parathyroid surgery, certified by the German Association of Surgery (DGAV) [4]. All patients had pre- and postoperative vocal cord (VC)-test by direct laryngoscopy by an independent ENT-specialist. All operations were attended by a certified Endocrine Surgeon and surgical procedures were open minimal incision thyroidectomies (OMIT) via collar incisions, applying minimal invasive techniques including high-energy devices as well as standardized preparation techniques. Intraoperative neuromonitoring (IONM) of the vagal and the recurrent laryngeal nerve (RLN) was routinely performed using previously published protocols. In case of an intraoperative non transitory loss-of-signal (ntLOS), this was documented and potential reasons recorded. Primary ntLOS was defined as no electrophysiological answer during vagal nerve stimulation at the beginning of the operation, while secondary ntLOS was defined a LOS occurring during operation, often combined with a damaging action (e.g. traction, heat, section) giving a reason for the LOS. Structural integrity of the RLN was always checked. For special indications (e.g. re-do, malignancy, immense volume extent) continuous neuromonitoring (CIONM) was available. To avoid bilateral palsies, in case of LOS at the first side, a change of strategy was always considered and the resection of the second side was postponed until normal vocal cord function was proven or regained.

Postoperatively, every patient had a second VC-test to document the vocal cord function. In case of a VC-dysfunction (VCD) we didn't apply medical (e.g. corticosteroids) or speech therapy regularly, but patients were sent to ENT-specialist 4 weeks after surgery for further evaluation and initiation of speech therapy in case of persistence.

*Postsurgical Follow Up Data*

All patients with postoperative VCD were subjected to a detailed follow-up program. To this end, the Endocrine Centers Outcomes Research Unit used regular (i.e. monthly) structured telephone interviews to assess the state of the patient and the remaining extent of the dysfunction. Follow-up was terminated only if a full recovery had been validated by either clinical recovery or confirmation after vocal cord examination from an ENT. ENT visits were scheduled 4 and 12 weeks after surgery for all patients with VCD.

*Handling of Data and Statistical Analysis*

All perioperative data were prospectively documented as individual datasets according to the thyroid-surgery-module of the StuDoQ-Quality Assurance Registry of the German Surgical Association (DGAV) after informed consent [4]. All data computed for this publication were pseudonymized or aggregate non-individual data. Descriptive statistic was used to summarize patients' characteristics. Continuous variables are reported as mean and standard deviation (SD) or median and interquartile range and were compared between groups using two-sample independent t-tests. Categorical variables were summarized as frequencies (%) and compared using Pearson's chi-squared test or Fisher's exact test where applicable. Logistic regression analysis was used to determine independent predictors of recovery within 12 weeks after surgery. Results are reported as odds ratio (OR) with the corresponding 95% confidence interval (CI).

SPSS version 25 (IBM corp., Armonk, NY) and R Studio version 3.2.1. (RStudio, Inc., Boston, MA) were used for data analysis. P-values $< 0.05$ (two- tailed) were considered statistically significant.

*Ethics Approval and Consent to Participate*

This study was conducted in cooperation with the Endocrine Centers certified Outcomes Research Unit and accredited by the Institutional Review Board of the Diakonie-Klinikum Stuttgart.

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The methodology was in accordance with the Declaration of Helsinki and the approved guidelines. All data enrolled in this study were obtained from the StuDoQ quality assurance database, for which informed consent had been obtained. No data from a human participant research study or personal identifying information was included in this study. Informed consent was not required for this secondary analysis enabling quality assurance.

## Results

During the 12-month period a total of 1097 surgeries for thyroid pathologies were performed. Thyroid resections comprised of 538 complete resections (505 total thyroidectomies (TTX) and 33 two-staged thyroidectomies) and 559 less than total resections (515 hemithyroidectomies and 44 comprising of central resections as well as bilateral subtotal resections such as Hartley, Dunhill, Enderlein-Hotz). Resulting in a total of n= 1591 nerves at risk. A total of n= 82 PT-VCD were detected, of which n=4 patients were excluded due to preexisting VCD (2 tumor-related, 2 recurrent goiters), leaving a cohort of n= 78 patients for analysis.

The entire cohort including n= 1097 thyroid surgeries was described previously [5]. In brief, 74.5% of all thyroid patients were female, 85.9% had benign conditions including n= 86 patients with Graves' disease, all of which had total thyroidectomies (7.8% of the entire cohort, 15.9 % of TTX). Malignant thyroid pathologies were found in n= 155 patients (14.1% of the entire cohort, 27.9 % of TTX), of which n= 67 patients had a systematic dissection of cervical lymph nodes involving Robbins-Regions VI and VII (6.1% of the cohort, 12.8 % of TTX). N= 126 patients (11.5%) had undergone previous surgery to the neck including n= 54 (4.9%) surgeries for recurrent benign goiter.

*Postsurgical Vocal Cord Dysfunction - Patient Characteristics*

Patient characteristics of all n= 78 postoperative VCD patients are displayed in Table 1. N= 54 patients were female (69.2) and n= 34 underwent a thyroidectomy (43.6%).

**Table 1.** Baseline characteristics of the overall cohort.

| N (%) | Overall n= 78 |
|---|---|
| Malignant | 11 (14.1) |
| ENT complete recovery | 50 (64.1) |
| ENT incomplete recovery | 14 (17.9) |
| Clinical recovery | 11 (14.9) |
| Side of the paresis* | |
| - left | 48 (61.5) |
| - right | 33 (42.3) |
| Paresis on contralateral side | 3 (3.8) |
| ntLOS | 46 (59.0) |
| - primary | 10 (12.8) |
| - secondary | 36 (46.2) |
| Re-Operation | 7 (9.0) |
| Central lymphadenectomy | 6 (7.7) |
| Graves' disease | 6 (7.7) |
| Female Gender | 54 (69.2) |
| Thyreoidectomy | 34 (43.6) |

Abbreviations: ENT= ear, nose, and throat specialist, ENT complete recovery= complete regain of the vocal cord mobility documented by an ENT, ENT incomplete recovery= markedly improved vocal cord mobility as documented by a vocal cord test with a fully recovered voice, documented by an ENT, ntLOS= nion transitory loss of signal of the intraoperative neuromonitoring. *n=3 bilateral paresis.

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Histopathological diagnoses confirmed benign thyroid conditions in n= 67 (85.9%) and included n= 6 patients with Graves' disease (7.7%) and n= 7 redo-operations (9.0 %). Eleven patients were confirmed to have thyroid cancer (14.1%) and a dissection of the central cervical lymph nodes had been carried out in n= 6 patients (7.7%).

Non transitory loss of signal of the intraoperative neuromonitoring was documented in n=46 cases (59%), in n= 10 cases a primary signal loss was recorded (12.8%). Although n=3 patients had a bilateral affection of VCD, none led to a tracheotomy, and two patients had a full recovery within 3 months. The third patient showed an incomplete recovery on the left side at the last VCL follow-up visit 18 months postoperatively but a persistent paresis on the right side.

Complete recovery was confirmed by an ENT specialist in n= 50 cases (64.1%), while n= 14 patients (17.9%) still showed reduced vocal cord mobility at the last ENT consultation, and n= 11 patients refused a follow-up visit at the ENT-specialist but reported clinical recovery (14.9%). A total of n= 3 patients (3.8%) did not recover during the clinical follow-up.

*Postsurgical Vocal Cord Dysfunction - Time Course of Recovery*

As depicted in Figures 1 and 2, median recovery time was 15 weeks (IQR 6-23 weeks) for the n= 75 patients who recovered within the median follow-up time of 16 weeks (IQR 6-24 weeks). Median follow-up of the n= 3 patients without confirmed recovery within the study period was 70 weeks (IQR 61-71 weeks). The slope of the curve of recovery was steepest within the 4 to 24 weeks post-surgery interval. After 6 months 25.6% (n=20) had not yet recovered, and n=7 patients (9%) recovered later than 12 months after initial surgery. The initiation of vocal cord therapy at 4 weeks postoperatively is represented by an increasing slope after the 4 week interval.

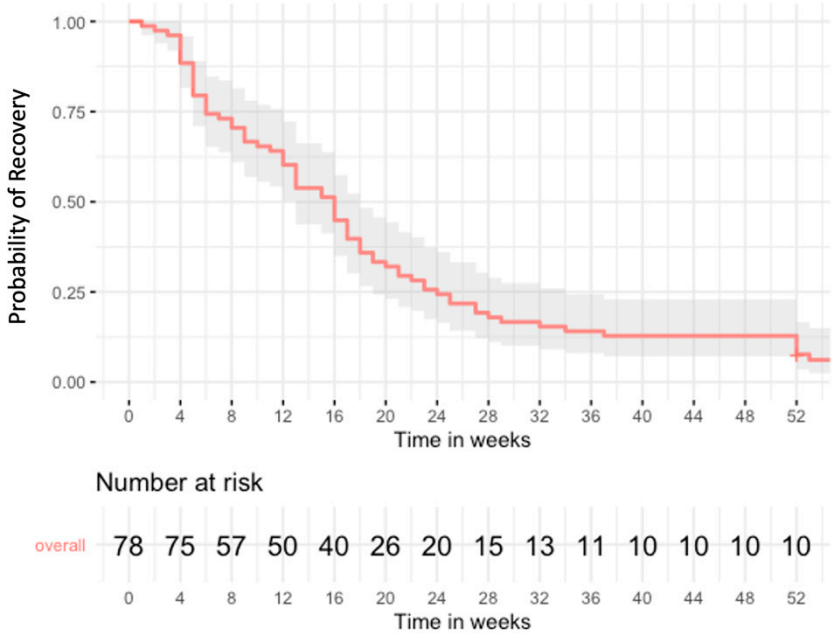


**Figure 1.** Kaplan-Meier estimates of time to recovery for all VCD patients.

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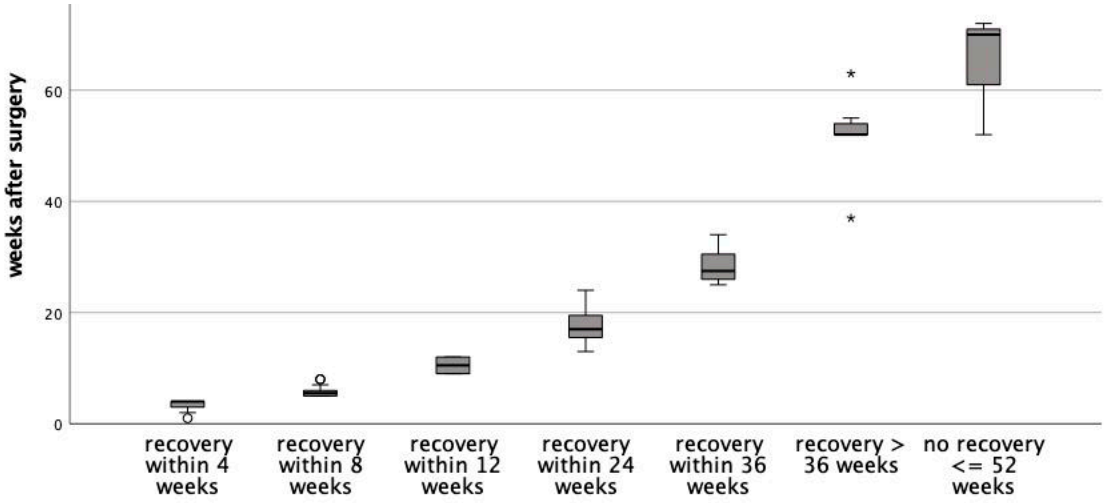


**Figure 2.** Time to recovery for all patients stratified according to intervals of 4 weeks.

*Postsurgical Vocal Cord Dysfunction –Predictors for Time to Recovery*

In order to further explore the possibility of clinicopathological variables to predict time to recovery, patients were stratified according to time to recovery within 12 weeks or later recovery. A total of n=31 patients (39,7%) recovered within 12 weeks after surgery. Documented by VCL of an ENT-specialist, recovery was more frequent in the group recovering within 12 weeks (80.6% versus 53.2%, p= 0.017), while clinical recovery was the only documented recovery in 21.3% of the patients with later recovery than 12 weeks (3.2% versus 21.3%, p= 0.0042). LOS was documented in 68.1% in the later recovery group compared to 45.2% in the group of patients recovering within 12 weeks (p= 0.06) and secondary signal loss was more frequent in the later recovery group (p=0.02). Otherwise, the baseline characteristics were comparable between the two groups.

**Table 2.** Baseline characteristics for recovery within 12 weeks compared to later/no recovery.

| N (%) | Recovered within 12 weeks n= 31 | Delayed/no recovery N= 47 | p-value |
|---|---|---|---|
| Malignant | 3 (9.7) | 8 (17) | 0.511 |
| ENT complete recovery | 25 (80.6) | 25 (53.2) | **0.017** |
| ENT incomplete recovery | 5 (16.1) | 9 (19.1) | 1.00 |
| Clinical recovery | 1 (3.2) | 10 (21.3) | **0.042** |
| Side of the paresis * | | | |
| - left | 18 (58.1) | 30 (63.8) | 0.641 |
| - right | 15 (48.4) | 18 (38.3) | 0.483 |
| Paresis on contralateral side | 2 (6.5) | 1 (2.1) | 0.560 |
| ntLOS | 14 (45.2) | 32 (68.1) | **0.06** |
| - primary | 5 (16.1) | 5 (10.6) | 0.507 |
| - secondary | 9 (29.0) | 27 (57.4) | **0.02** |
| Re-Operation | 3 (9.7) | 4 (8.5) | 1.00 |
| Central lymphadenectomy | 1 (3.2) | 5 (10.6) | 0.393 |
| Graves' disease | 3 (9.7) | 3 (6.4) | 0.677 |
| Female Gender | 20 (64.5) | 34 (72.3) | 0.617 |
| Thyreoidectomy | 15 (48.4) | 19 (40.4) | 0.641 |

Abbreviations: ENT= ear, nose, and throat specialist, ENT complete recovery= complete regain of the vocal cord mobility documented by an ENT, ENT incomplete recovery= markedly improved vocal cord mobility as documented by a vocal cord test with a fully recovered voice, documented by an ENT, LOS= non transitory loss of signal of the intraoperative neuromonitoring. *n=3 bilateral VC-involvement.

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As depicted in Table 3, univariable logistic regression analysis revealed non transitory loss of signal and more specific, secondary non transitory loss of signal as single independent predictor of recovery later than 12 weeks (OR for recovery within 12 weeks 0.303 (95%CI 0.115-0.797), p= 0.016). Due to the results of the univariable logistic regression analysis, we refrained from further analyses.

**Table 3.** Univariable logistic regression of recovery within 12 weeks after thyroid surgery (n= 31 versus n= 47).

| | OR | Lower CI | Upper CI | p-value |
|---|---|---|---|---|
| Gender | 0.70 | 0.26 | 1.84 | 0.465 |
| Thyroidectomy vs. lobectomy | 1.38 | 0.55 | 3.45 | 0.488 |
| Right sided paresis vs.left | 1.51 | 0.60 | 3.78 | 0.378 |
| | | | | |
| Graves' disease | 1.57 | 0.30 | 8.34 | 0.596 |
| Thyroid Cancer | 0.52 | 0.13 | 2.15 | 0.368 |
| Involvement of Lymphnodes | 0.280 | 0.03 | 2.52 | 0.256 |
| Reoperation | 1.15 | 0.24 | 5.54 | 0.860 |
| Type of ntLOS | 0.39 | 0.15 | 0.98 | **0.046** |
| - primary ntLOS | 1.615 | 0.426 | 6.124 | 0.481 |
| - secondary ntLOS | 0.303 | 0.115 | 0.797 | **0.016** |

Abbreviations: CI= confidence interval, LAD= lymphadenectomy, ntLOS= non transitory loss of signal during intraoperative neuromonitoring. Primary nt-LOS: no VC-EMG obtained during surgery despite qs-efforts, secondary ntLOS: VC-EMG at normal values at first measurement gets "lost" during surgery.

## Discussion

The management of post-thyroidectomy vocal cord paralysis (PT-VCP) is a critical concern in endocrine surgery, given its profound impact on patients' quality of life. Vocal cord paralysis, especially when persistent, can lead to significant morbidity, including dysphonia, aspiration, and respiratory distress [6]. Accidental transection of the nerve is a rare occurrence. Most "injuries" to the nerve leave no visible traces and may be caused by traction or thermal affections (non-transection injury). There are few data on the recovery time of non-transection recurrent nerve injury, however, the reported duration is very heterogeneous, ranging from a few weeks to many months [7]. The variability in recovery outcomes highlights the need for a nuanced understanding of the factors influencing nerve recovery and the role of intraoperative neuromonitoring (IONM). The varying assessments of the duration of PT-VCD result in very different starting points for postoperative speech therapy in everyday clinical practice. Some clinics start immediately after surgery, while others wait a few weeks, based on the idea that many PT-VCD cases recover quite quickly. Our study provides an in-depth analysis of the recovery patterns and prognostic IONM-indicators of non-transotory PT-VCD, contributing valuable insights to the existing body of literature.

One of the key findings of our study is the heterogeneity in recovery time among patients with PT-VCP. We observed, that while a substantial proportion of patients (31%) regained vocal cord function within 12 weeks, a notable 9% required more than 12 months for recovery. And only a small percentage of 12% recovered within 4 weeks, with the median recovery time exceeding 4 months. This wide range of recovery times is consistent with the findings of numerous studies that emphasize the unpredictable natuDe of recovery from recurrent laryngeal nerve (RLN) injury. In a comprehensive review, Randolph et al. [3] noted that while many patients show improvement within the first 6 months, some may experience prolonged recovery periods, with a small percentage never fully recovering.

The role of IONM in thyroid surgery has been a topic of considerable debate. Our study reinforces the importance of IONM, particularly in detecting loss of signal (LOS) during surgery. We found that the occurrence of non transitory LOS, especially secondary, non-transitory LOS was significantly associated with delayed recovery, underscoring the prognostic value of IONM. This finding aligns with the work of Dralle et al. [8], who demonstrated that LOS is a strong predictor of

 doi:10.20944/preprints202603.0516.v1



post-thyroidectomy vocal cord dysfunction. Moreover, Schneider et al. [9] reported that the use of continuous IONM to anticipate LOS during thyroid surgeries resulted in fewer permanent vocal fold palsies compared with intermittent IONM. And we have previously reported that IONM, when used routinely, reduces the rate of bilateral vocal cord dysfunction in planned bilateral thyroid procedures [10]. Combining the results of our studies supports the finding that an ntLOS can predict prolonged recovery, reinforcing the recommendation to use IONM during thyroidectomy. Not only can the surgery be stopped if there is LOS on the first side to avoid a bilateral paresis, but the LOS also provides the treatment team with the information that they may need to wait several months for recovery of the first side before proceeding with surgery on the opposite side.

Interestingly, our study did not find a significant difference in recovery based on the side of RLN injury (left vs. right) or the extent of thyroidectomy (total vs. lobectomy) nor weight of the resection specimen. This observation contrasts with some reports in the literature that suggest a higher risk of permanent PT-VCP with right-sided injuries, possibly due to the shorter and more vulnerable course of the right RLN. A study by Bergenfelz et al. [11] suggested that unilateral paresis is may be associated with older age, intrathoracic goiter or thyrotoxicosis, but our findings suggest that other factors, such as the extent of neural disruption as displayed by impaired neuromonitoring such as a non-transitory LOS, may play a more significant role in determining recovery.

The initiation of vocal cord therapy is another critical aspect of managing PT-VCP. Our study supports the early initiation of therapy, particularly in patients with documented ntLOS during surgery. Early therapeutic intervention, particularly within the first 4 to 24 weeks post-surgery, appears to be crucial for optimizing outcomes. This is consistent with findings from a study by Ruoppolo [12], who found that early intervention can enhance vocal outcomes, both on voice recovery and on quality of life. The goal of treating patients with unilateral vocal fold paralysis is to restore normal phonatory function without aspiration. Several methods have been devised to restore near-normal phonatory function, including voice therapy alone or in combination with injection medialization, laryngoplasty, or laryngeal reinnervation [13].

The clinical implications of our findings are multifaceted (multiple). First, the detection of ntLOS during surgery should prompt a more aggressive (vigorous) postoperative management approach, including early referral to speech therapy and close monitoring of vocal function. This proactive strategy could lead to improved patient outcomes and satisfaction, as early intervention has been shown to mitigate the long-term effects of PT-VCD. Moreover, our data support the routine use of IONM in thyroid surgery, not only as a tool to prevent bilateral PT-VCD but also as a means to provide valuable prognostic information for unilateral PT-VCD recovery. Although a few years ago IONM was not recommended as the standard of care for thyroidectomy [14], recent analyses of large registries have shown that the use of IONM is associated with a lower rate of postoperative PT-VCP [15]. One reason for this may be that the use of neuromonitoring allows for a more rapid identification of the vocal cord nerves [16]. And attempts to develop energy-based devices that also allow nerve stimulation, especially for endoscopic cervical surgery, confirm the growing understanding of the importance of nerve control [17].

Our study also highlights the need for a personalized approach to managing PT-VCP. Factors such as the presence of comorbid conditions, the extent of RLN injury, and the timing of therapeutic interventions should be considered when planning postoperative care. Since systemic conditions can significantly impact nerve healing and recovery outcomes such as diabetic neuropathy and chemotherapy-induced peripheral neuropathy, leading to impaired nerve function and regeneration [18], patients with diabetes or other systemic diseases may have a delayed or impaired healing response, necessitating a more tailored approach to their care.

It should be emphasized that although risk factors for paresis have been and are being researched [19], little is known about the factors influencing the subsequent recovery process or the duration of paresis. It should also be noted that even in the absence of laryngoscopically detectable impairment of vocal cord motility, subjective voice impairment may be a postoperative limitation for the patient. Neuromonitoring in thyroid surgery appears to improve outcomes related to baseline frequency and

 doi:10.20944/preprints202603.0516.v1



high-pitch voice in the early postoperative period. It could effectively reduce temporary phonation alterations after surgery [20].

Despite the strengths of our study, including a comprehensive follow-up program and the use of objective measures to assess vocal cord function, there are limitations that should be acknowledged. The retrospective design of the study and the reliance on data from a single center may limit the generalizability of our findings. Additionally, the subjective nature of patient-reported outcomes, despite being supplemented by objective assessments, introduces the potential for bias. Future research should focus on validating our findings in larger, multicenter cohorts and exploring the integration of IONM data with other clinical variables, such as patient demographics and comorbid conditions, to develop more comprehensive predictive models for PT-VCP recovery.

In addition, the role of advanced imaging and electrophysiologic studies in assessing RLN function and predicting recovery outcomes warrants further investigation. Techniques such as transcutaneous laryngeal ultrasound for vocal cord assessment are easy to perform, non-invasive, and potentially painless alternatives for evaluating vocal cord function in selected patients [21]. And stroboscopic and intra- and extra laryngeal electromyography have shown promise in assessing RLN integrity and guiding therapeutic decisions, including identifying the nature of postoperative recurrent laryngeal nerve dysfunction, especially in cases of normal intraoperative neuromonitoring but postoperative impaired vocal cord function [22].

In conclusion, our study contributes to the growing body of evidence supporting the importance of early detection and intervention in managing PT-VCP. The use of intraoperative neuromonitoring, particularly the detection of nt-LOS, plays a crucial role in predicting recovery outcomes and should be considered standard practice in thyroid surgery. By understanding the factors that influence PT-VCP recovery, including the role of early therapeutic interventions and the impact of systemic conditions, surgeons can better manage patient expectations and implement personalized care strategies that improve overall outcomes.

**Author Contributions:** Conceptualization, L.G., S.S., C.S., S.H. and A.Z.; methodology, L.G., S.S., A.Z. and C.S.; software, L.G.; validation, S.S., C.S. and A.Z.; resources, S.H., J.A., M.S., M.B. and J.W.; data curation, C.S. and J.A.; writing—original draft preparation, L.G., S.S., C.S. and A.Z.; writing—final review and editing, C.S., S.S., L.G., M.S., A.Z., visualization, J.W., M.B. and J.A. All authors have read and agreed to the published version of the manuscript.

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**Informed Consent Statement:** Ethical committees determined that the data presented in this article do not represent a human participant research study, do not include personal identifying information, and were carried out in accordance with the relevant legislation for the purpose of quality monitoring and quality assurance. Therefore, this analysis did not require informed consent other than the consent obtained prior to entering data into the StuDoQ Database.

**Data Availability Statement:** The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Schneider R, Machens A, Lorenz K et al. Intraoperative nerve monitoring in thyroid surgery-shifting current paradigms. Gland Surg 2020; 9: S120-S128. doi:10.21037/gs.2019.11.04
2. Huang TY, Tseng HY, Frattini F et al. The INMSG Survey on the Loss of Signal Management on the First Side During Planned Bilateral Thyroid Surgery. J Otolaryngol Head Neck Surg 2024; 53: 19160216241265684. doi:10.1177/19160216241265684

 doi:10.20944/preprints202603.0516.v1




3. Randolph GW, Dralle H, International Intraoperative Monitoring Study G et al. Electrophysiologic recurrent laryngeal nerve monitoring during thyroid and parathyroid surgery: international standards guideline statement. Laryngoscope 2011; 121 Suppl 1: S1-16. doi:10.1002/lary.21119
4. DGAV. Thyroid surgery quality assurance registry of the German Association of Surgeons (DGAV); StuDoQ|Thyroid. In; 2021
5. Guglielmetti L, Schmidt S, Busch M et al. How Long Does It Take to Regain Normocalcaemia in the Event of Postsurgical Hypoparathyroidism? A Detailed Time Course Analysis. J Clin Med 2022; 11. doi:10.3390/jcm11113202
6. Valley ZA, Karp A, Garber D. Safety and Adverse Events of Medialization Thyroplasty: A Systematic Review. Laryngoscope 2024; 134: 1994-2004. doi:10.1002/lary.31141
7. Schneider M, Dahm V, Passler C et al. Complete and incomplete recurrent laryngeal nerve injury after thyroid and parathyroid surgery: Characterizing paralysis and paresis. Surgery 2019; 166: 369-374. doi:10.1016/j.surg.2019.05.019
8. Dralle H, Sekulla C, Haerting J et al. Risk factors of paralysis and functional outcome after recurrent laryngeal nerve monitoring in thyroid surgery. Surgery 2004; 136: 1310-1322. doi:10.1016/j.surg.2004.07.018
9. Schneider R, Sekulla C, Machens A et al. Postoperative vocal fold palsy in patients undergoing thyroid surgery with continuous or intermittent nerve monitoring. Br J Surg 2015; 102: 1380-1387. doi:10.1002/bjs.9889
10. Smaxwil C, Aleker M, Altmeier J et al. Neuromonitoring of the Recurrent Laryngeal Nerve Reduces the Rate of Bilateral Vocal Cord Dysfunction in Planned Bilateral Thyroid Procedures. J Clin Med 2021; 10. doi:10.3390/jcm10040740
11. Bergenfelz A, Jansson S, Kristoffersson A et al. Complications to thyroid surgery: results as reported in a database from a multicenter audit comprising 3,660 patients. Langenbecks Arch Surg 2008; 393: 667-673. doi:10.1007/s00423-008-0366-7
12. Ruoppolo G, Mariani L, Quaglieri S et al. Unilateral vocal fold paralysis post-thyroidectomy: does early intervention allow for better voice recovery? Eur Rev Med Pharmacol Sci 2021; 25: 1177-1184. doi:10.26355/eurrev_202102_24820
13. Benninger MS, Crumley RL, Ford CN et al. Evaluation and treatment of the unilateral paralyzed vocal fold. Otolaryngol Head Neck Surg 1994; 111: 497-508. doi:10.1177/019459989411100419
14. Malik R, Linos D. Intraoperative Neuromonitoring in Thyroid Surgery: A Systematic Review. World J Surg 2016; 40: 2051-2058. doi:10.1007/s00268-016-3594-y
15. Staubitz JI, Watzka F, Poplawski A et al. Effect of intraoperative nerve monitoring on postoperative vocal cord palsy rates after thyroidectomy: European multicentre registry-based study. BJS Open 2020; 4: 821-829. doi:10.1002/bjs5.50310
16. Lee E, Lee K, Yu HW et al. Comparison of Recurrent Laryngeal Nerve Identification Time in the Lower Central Triangle during Thyroid Surgery Using Neurophysiological Mapping and Monitoring. Medicina (Kaunas) 2021; 57. doi:10.3390/medicina57080748
17. Zhang D, Li S, Dionigi G et al. Stimulating and dissecting instrument for transoral endoscopic thyroidectomy: proof of concept investigation. Surg Endosc 2020; 34: 996-1005. doi:10.1007/s00464-019-06936-2
18. Samaddar S, Redhwan MAM, Eraiah MM et al. Neurotrophins in Peripheral Neuropathy: Exploring Pathophysiological Mechanisms and Emerging Therapeutic Opportunities. CNS Neurol Disord Drug Targets 2025; 24: 91-101. doi:10.2174/0118715273327121240820074049
19. Tabriz N, Muehlbeyer S, Weyhe D et al. Risk Factors for Recurrent Laryngeal Nerve Palsy in Thyroid Surgery: A Single Center Experience of 1147 Procedures with Intermittent Intraoperative Neuromonitoring. J Pers Med 2024; 14. doi:10.3390/jpm14070714
20. Baek SK, Lee K, Oh D et al. Efficiency of intraoperative neuromonitoring on voice outcomes after thyroid surgery. Auris Nasus Larynx 2017; 44: 583-589. doi:10.1016/j.anl.2017.01.009
21. Rossi L, Papini P, De Palma A et al. Surgeon-performed transcutaneous laryngeal ultrasound for vocal cord assessment after total thyroidectomy: a prospective study : Original article. Langenbecks Arch Surg 2024; 409: 183. doi:10.1007/s00423-024-03362-4

 doi:10.20944/preprints202603.0516.v1



22. Dralle H, Kruse E, Hamelmann WH et al. [Not all vocal cord failure following thyroid surgery is recurrent paresis due to damage during operation. Statement of the German Interdisciplinary Study Group on Intraoperative Neuromonitoring of Thyroid Surgery concerning recurring paresis due to intubation]. Chirurg 2004; 75: 810-822. doi:10.1007/s00104-004-0857-1