

Surgical complexity and early post-operative parathyroid function following incidental parathyroidectomy during thyroidectomy

Complejidad quirúrgica y función paratiroidea postoperatoria temprana tras paratiroidectomía incidental durante tiroidectomía

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Abstract

Objective: This study evaluated whether surgical complexity influences post-operative parathyroid function in patients with IP.

Methods: A retrospective cohort study was conducted including 371 patients who underwent thyroidectomy between 2017 and 2020. Seventy-two patients (19.4%) with histologically confirmed IP were classified into total thyroidectomy, completion thyroidectomy, and substernal thyroidectomy groups. Post-operative day-1 parathyroid hormone (PTH) level was the primary outcome. Secondary outcomes included calcium levels and biochemical hypocalcemia. **Results:** IP was identified in 72 patients (19.4%). The number of excised parathyroid glands and autotransplantation rates were similar among groups. Patients undergoing substernal thyroidectomy had the lowest post-operative day-1 PTH levels (13.9 pg/mL), whereas the highest levels were observed after completion thyroidectomy (24.8 pg/mL). Although differences in post-operative PTH and calcium levels were not statistically significant, lower post-operative parathyroid function was observed with increasing surgical complexity. Biochemical hypocalcemia occurred in 84.6% of substernal thyroidectomy patients compared with 72.3% and 41.7% of total and completion thyroidectomy patients, respectively ($p = 0.051$). **Conclusions:** Surgical complexity may adversely affect early post-operative parathyroid function after IP.

Keywords: Incidental parathyroidectomy. Thyroidectomy. Hypocalcemia. Parathyroid hormone.

Resumen

Objetivo: Este estudio evaluó si la complejidad quirúrgica influye en la función paratiroidea postoperatoria en pacientes con PI. **Métodos:** Estudio retrospectivo de cohorte que incluyó 371 pacientes sometidos a tiroidectomía entre 2017 y 2020. Se identificaron 72 pacientes (19.4%) con PI confirmada histológicamente, clasificados en grupos de tiroidectomía total, tiroidectomía de completamiento y tiroidectomía por bocio substernal. El desenlace principal fue el nivel de hormona paratiroidea (PTH) en el primer día postoperatorio. Los desenlaces secundarios fueron los niveles de calcio y la hipocalcemia bioquímica. **Resultados:** La PI se identificó en 72 pacientes (19.4%). El número de glándulas paratiroides extirpadas y las tasas de autotrasplante fueron similares entre los grupos. Los pacientes sometidos a tiroidectomía por bocio substernal presentaron los niveles más bajos de PTH postoperatoria (13.9 pg/ml), mientras que los más altos se observaron tras la tiroidectomía de completamiento (24.8 pg/ml). Aunque las diferencias en los niveles de PTH y calcio no fueron estadísticamente significativas, se observó una menor función paratiroidea con el aumento de la complejidad quirúrgica. La hipocalcemia ocurrió en el 84.6%, el 72.3% y el 41.7% de los pacientes, respectivamente ($p = 0.051$). **Conclusiones:** La complejidad quirúrgica puede afectar

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negativamente la función paratiroidea temprana tras una PI.

Palabras clave: Paratiroidectomía incidental. Tiroidectomía. Hipocalcemia. Hormona paratiroidea.

Introduction

Globally, thyroidectomy represents the cornerstone of endocrine surgery practice. Despite advances in surgical techniques and technology, hypocalcemia remains the most frequent complication, significantly affecting patient comfort and hospitalization costs. One of the primary causes of post-operative hypocalcemia is incidental parathyroidectomy (IP), defined as the unintentional removal of parathyroid tissue during thyroid surgery.

The reported incidence of IP varies widely in the literature, ranging from 3% to over 20%, depending on the extent of dissection and the diligence of pathological examination.¹⁻⁵ Previous studies have clearly established thyroid malignancy and central neck dissection as major risk factors for IP.¹⁻⁴ However, the impact of specific “surgical difficulties”—such as substernal extension or completion thyroidectomy—on the functional outcome of patients who have already undergone IP is less clear.

Substernal goiters present unique anatomical challenges due to distorted vascular planes and limited visualization of the lower parathyroid glands.^{1,6} Similarly, completion thyroidectomies are associated with fibrosis and altered anatomy.^{2,6}

Although several studies have investigated the incidence and risk factors of IP, limited data are available regarding the influence of surgical complexity on post-operative parathyroid function once incidental gland removal has occurred. We hypothesized that procedures associated with greater anatomical distortion and technical difficulty may result in more pronounced post-operative biochemical impairment despite similar numbers of excised parathyroid glands. Therefore, the aim of the present study was to evaluate the impact of surgical complexity on early post-operative parathyroid function in patients with histologically confirmed IP.

Methods

Study design and population

This retrospective cohort study was conducted at a single center (University Hospital, Department of

General Surgery). The medical records of 371 patients who underwent thyroidectomy between 2017 and 2020 were reviewed. Among these, 72 patients (19.4%) with histopathologically confirmed incidental parathyroid tissue in the resection specimen were included in the detailed analysis.

Exclusion criteria

Patients with pre-existing calcium metabolism disorders, Vitamin D deficiency, preoperative hypocalcemia, chronic renal failure, or those undergoing parathyroidectomy for primary hyperparathyroidism were excluded from the study.

Surgical categorization

To analyze the impact of surgical difficulty, patients were divided into three groups:

- Group 1 (Standard): total thyroidectomy (TT) – representing primary cases with standard cervical access.
- Group 2 (Re-operative): completion thyroidectomy – representing cases with potential adhesive risks but limited to unilateral dissection.
- Group 3 (Complex Access): substernal (Intrathoracic) thyroidectomy – representing cases requiring mediastinal maneuver and high risk of vascular compromise.

Surgical complexity was categorized a priori according to the anticipated degree of anatomical distortion, operative difficulty, and potential risk of parathyroid vascular compromise. Standard TT was considered the reference procedure, completion thyroidectomy represented re-operative surgery with altered tissue planes, and substernal thyroidectomy represented the highest level of surgical complexity due to mediastinal extension, limited exposure, and increased technical demands.

Biochemical analysis

Serum calcium (Ca), phosphorus, and parathyroid hormone (PTH) levels were measured preoperatively,

on post-operative day 1, and at the first outpatient follow-up. Clinical hypocalcemia was managed with oral calcium and calcitriol supplementation according to our clinic's standard protocol. The primary outcome was post-operative day-1 PTH level, whereas post-operative calcium level, biochemical hypocalcemia, and length of hospital stay were evaluated as secondary outcomes.

Statistical analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) software (IBM SPSS Statistics, version 26.0). Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as numbers and percentages. Continuous variables were compared using one-way analysis of variance, while categorical variables were analyzed using the Chi-square test. $p < 0.05$ was considered statistically significant.

This study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (Supplementary Data 1) guidelines.

This study was a retrospective analysis of existing data. Patients and the public were not involved in the design, conduct, reporting, or dissemination plans of the research.

Results

Baseline demographic characteristics, parathyroid gland findings, and post-operative biochemical outcomes according to surgical complexity are presented in table 1.

Demographic characteristics

A total of 371 thyroidectomy cases were screened, and IP was identified in 72 patients, yielding an incidence rate of 19.4%. The majority of the study cohort consisted of patients operated on for thyroid malignancy (80.5%), reflecting the oncological profile of our center.

The mean age of the patients was 45.6 ± 14.2 years. When analyzed by groups, patients in the substernal thyroidectomy group were significantly older (51.9 ± 14.8 years) compared with those undergoing standard TT (42.9 ± 14.5 years) ($p = 0.041$).

Parathyroid gland characteristics

The number of inadvertently removed parathyroid glands was comparable across surgical groups. The mean number of excised glands was 1.13 in the TT group, 1.25 in the completion thyroidectomy group, and 1.23 in the substernal thyroidectomy group ($p = 0.596$).

Removal of two or more parathyroid glands occurred in 10.6% of patients undergoing TT, 16.7% in completion thyroidectomy, and 23.1% in substernal thyroidectomy ($p = 0.494$).

Parathyroid autotransplantation was performed in 19.1% of TT cases, 16.7% of completion thyroidectomies, and 15.4% of substernal thyroidectomies, with no statistically significant difference between groups ($p = 0.944$).

Biochemical outcomes

Post-operative day-1 PTH level was defined as the primary outcome measure of the study. Early post-operative parathyroid function varied according to surgical complexity. Patients undergoing substernal thyroidectomy demonstrated the lowest mean post-operative day-1 PTH level (13.90 pg/mL), whereas the highest level was observed in the completion thyroidectomy group (24.81 pg/mL). Patients undergoing standard TT exhibited intermediate values (17.62 pg/mL). Although these differences did not reach statistical significance ($p = 0.135$), the observed distribution suggests a tendency toward greater post-operative parathyroid dysfunction with increasing surgical complexity.

A similar pattern was observed for post-operative calcium levels. Patients in the substernal thyroidectomy group demonstrated the lowest post-operative day-1 calcium concentration (7.93 mg/dL), whereas calcium levels were slightly higher in the standard TT and completion thyroidectomy groups. However, these differences were not statistically significant ($p = 0.549$).

Biochemical hypocalcemia occurred in 34 of 47 patients (72.3%) undergoing TT, 5 of 12 patients (41.7%) undergoing completion thyroidectomy, and 11 of 13 patients (84.6%) undergoing substernal thyroidectomy. Although the difference did not reach statistical significance, a strong trend toward higher rates of biochemical hypocalcemia was observed among patients undergoing substernal thyroidectomy ($p = 0.051$).

Similarly, post-operative day-1 PTH levels below 15 pg/mL were identified in 22 patients (47.8%) in the

Table 1. Demographic, surgical, and early postoperative biochemical characteristics according to surgical complexity

Parameters	Total thyroidectomy (n = 47)	Completion thyroidectomy (n = 12)	Substernal thyroidectomy (n = 13)	p-value
Age (years), mean $\pm$ SD	42.9 $\pm$ 14.5	49.2 $\pm$ 12.4	51.9 $\pm$ 14.8	0.041
Malignancy, n (%)	39 (83.0)	10 (83.3)	10 (76.9)	0.88
Excised parathyroid glands, mean	1.13	1.25	1.23	0.596
≥ 2 parathyroid glands removed, n (%)	5 (10.6)	2 (16.7)	3 (23.1)	0.494
Parathyroid autotransplantation, n (%)	9 (19.1)	2 (16.7)	2 (15.4)	0.944
POD-1 Calcium (mg/dL), mean $\pm$ SD	8.12	8.24	7.93	0.549
POD-1 PTH (pg/mL), mean $\pm$ SD	17.62	24.81	13.90	0.135
Biochemical hypocalcemia (< 8.5 mg/dL), n (%)	34 (72.3)	5 (41.7)	11 (84.6)	0.051
POD-1 PTH < 15 pg/mL, n (%)	22 (47.8)	3 (25.0)	8 (66.7)	0.122
Length of hospital stay (days), mean $\pm$ SD	1.36	1.17	1.31	0.62

POD-1: post-operative day 1; PTH: parathyroid hormone.; SD: standard deviation.

TT group, 3 patients (25.0%) in the completion thyroidectomy group, and 8 patients (66.7%) in the substernal thyroidectomy group ($p = 0.122$).

Despite differences in biochemical parameters, the duration of hospitalization remained comparable among groups, with no significant difference in length of stay ($p = 0.62$).

Discussion

The present study investigated whether surgical complexity influences early post-operative parathyroid function among patients with histologically confirmed IP. Although no statistically significant differences were identified, patients undergoing substernal thyroidectomy demonstrated the lowest post-operative PTH levels, whereas completion thyroidectomy patients exhibited the highest levels. These findings suggest that the physiological consequences of IP may be influenced not only by gland removal itself but also by the operative environment in which gland injury occurs.

Traditional predictors of IP – including thyroid malignancy, central neck dissection, and extensive thyroid surgery – have been well described in the literature.^{1-5,7} Bai et al., in a large meta-analysis, demonstrated that more aggressive surgical approaches are associated with a higher likelihood of incidental parathyroid removal. Similarly, other studies have suggested that anatomical distortion caused by tumor infiltration or nodal dissection may increase the risk of parathyroid

gland injury during thyroidectomy. Recent national data have supported these observations. Büyükkasap et al. identified surgical extent and operative complexity as important contributors to IP risk in contemporary thyroid surgery practice.⁷ Likewise, Turgut et al. emphasized that IP remains one of the most unpredictable complications of thyroid surgery despite increasing surgical experience and technological advances.⁵

In the present study, patients undergoing substernal thyroidectomy exhibited lower post-operative PTH levels compared with other surgical groups. Although this difference did not reach statistical significance, the observed trend may reflect the anatomical and technical challenges associated with substernal goiters. Substernal thyroid enlargement may distort cervical anatomy, obscure visualization of the inferior parathyroid glands, and require traction during mediastinal mobilization, all of which may compromise the delicate vascular supply of the parathyroid glands.^{6,8-10} Although direct evidence regarding substernal thyroidectomy remains limited, the findings reported by Granata et al. suggest that preservation of parathyroid vascularization may be more important than simple gland preservation in maintaining post-operative parathyroid function.^{6,8-10}

Interestingly, the number of excised parathyroid glands and the rate of parathyroid autotransplantation were comparable among surgical groups. This observation represents one of the most relevant findings of the present study, as it suggests that differences in

post-operative parathyroid function cannot be explained solely by the quantity of parathyroid tissue removed. Instead, factors related to operative complexity, including gland devascularization, tissue manipulation, and impairment of the microvascular blood supply, may play a substantial role in determining post-operative parathyroid function. These findings support the concept that preservation of parathyroid viability may be at least as important as preservation of gland number during thyroid surgery.^{8,10-12} Notably, the observed differences in post-operative PTH levels occurred despite similar rates of multiple-gland excision and parathyroid autotransplantation. This finding reinforces the hypothesis that factors related to operative complexity may contribute to post-operative parathyroid dysfunction beyond the direct loss of parathyroid tissue.

Previous studies have emphasized that post-operative hypocalcemia following thyroidectomy is often multifactorial. Granata et al. highlighted that vascular compromise rather than simple gland excision may represent a key determinant of post-operative parathyroid dysfunction. Likewise, Sitges-Serra et al.¹¹ demonstrated that preservation of parathyroid gland vascularization is essential for maintaining post-operative parathyroid function. Similarly, Bozkaya et al. reported that perioperative parathyroid autotransplantation may influence post-operative calcium homeostasis and should be considered as part of a comprehensive gland-preservation strategy during thyroid surgery.¹³⁻¹⁶

From a clinical perspective, these findings highlight the importance of careful post-operative biochemical monitoring in patients undergoing complex thyroid procedures, particularly those involving substernal extension.^{6,11} Early identification of biochemical hypocalcemia allows prompt calcium and calcitriol supplementation and may prevent the development of symptomatic hypocalcemia.^{6,11,12} In addition, biochemical hypocalcemia occurred most frequently among patients undergoing substernal thyroidectomy, approaching statistical significance. Although the study was not powered to detect differences in clinical hypocalcemia, this finding further supports the possibility that complex surgical procedures may adversely affect residual parathyroid gland function.

In summary, although substernal thyroidectomy was associated with lower postoperative PTH levels, the difference did not reach statistical significance. Nevertheless, the observed trend supports the hypothesis

that surgical complexity may influence early post-operative parathyroid function following IP.

The present findings suggest that the biological consequences of IP may depend not only on the amount of parathyroid tissue removed but also on the complexity of the surgical environment in which gland injury occurs. Despite comparable numbers of excised parathyroid glands and similar rates of parathyroid autotransplantation across groups, patients undergoing substernal thyroidectomy demonstrated a tendency toward lower post-operative PTH levels. This observation supports the concept that preservation of parathyroid vascularization may be as important as preservation of gland number. Complex surgical procedures may expose the parathyroid glands to greater traction, manipulation, and vascular compromise, thereby contributing to post-operative biochemical hypoparathyroidism even when the glands are not directly excised. Consequently, the variability in post-operative parathyroid function observed after IP may be explained not only by gland loss but also by procedure-related factors affecting residual gland viability.

Clinical implications

From a practical perspective, patients undergoing complex thyroid procedures who experience IP may require closer biochemical surveillance during the early post-operative period. Particular attention should be given to substernal thyroidectomy cases, in which post-operative parathyroid dysfunction may develop despite apparent preservation of parathyroid tissue. Early recognition of biochemical deterioration may facilitate timely calcium and calcitriol supplementation and potentially reduce symptomatic hypocalcemia and unplanned healthcare utilization.^{15,16}

Limitations

This study has several limitations. First, its retrospective single-center design may introduce selection bias and limit generalizability. Second, the relatively small number of patients in the substernal thyroidectomy group may have limited the statistical power of the analysis. Third, intraoperative assessment of parathyroid perfusion was not available, preventing objective evaluation of gland vascularity. Therefore, the absence of statistically significant differences should be interpreted cautiously and does not necessarily exclude clinically meaningful associations. Prospective multicenter

studies with larger patient populations are needed to further clarify the relationship between surgical complexity and post-operative parathyroid function.

Conclusions

IP should not be regarded as a uniform surgical event. The present study suggests that its physiological impact may be influenced by the complexity of the surgical procedure in which it occurs. Although sub-sternal thyroidectomy was not associated with statistically significant differences in post-operative biochemical outcomes, a consistent trend toward lower early post-operative parathyroid function was observed. These findings support the hypothesis that factors beyond the number of excised glands, particularly vascular compromise and operative manipulation, may contribute to post-operative biochemical hypoparathyroidism. Larger prospective studies are required to further clarify the relationship between surgical complexity and post-operative parathyroid function.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical considerations

Protection of human subjects and animals. The authors declare that no experiments on humans or animals were performed for this research.

Confidentiality, informed consent, and ethical approval. The authors have obtained approval from the Ethics Committee for the analysis of routinely collected and anonymized clinical data; therefore, individual informed consent was not required. Relevant ethical recommendations have been followed.

Declaration on the use of artificial intelligence.

The authors declare that ChatGPT was used to edit the article for academic language and to correct spelling errors.

Supplementary data

Supplementary data are available at DOI: 10.24875/CIRU.26000173. These data are provided by the corresponding author and published online for the benefit of the reader. The contents of supplementary data are the sole responsibility of the authors.

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