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Predictors of Surgical Success in Parathyroidectomy: A Retrospective Study of Patients Receiving Renal Replacement Therapy with Secondary Hyperparathyroidism

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ABSTRACT

Objective: Secondary hyperparathyroidism (SHPT) is a complication of chronic kidney disease (CKD), requiring parathyroidectomy in refractory cases. This study evaluated subtotal and total parathyroidectomy outcomes in CKD patients and identified preoperative factors associated with surgical success.

Materials and Methods: Adult CKD patients who underwent parathyroidectomy for secondary hyperparathyroidism at Gazi University Faculty of Medicine were included in this retrospective study. Incomplete surgical resolution of SHPT was defined as persistent (failure to achieve a 50% reduction in parathyroid hormone (PTH) levels at the first postoperative hour, per the Miami criterion) or recurrent (PTH levels exceeding the target range six months postoperatively [2- to 9-fold the upper limit of normal, per KDIGO (Kidney Disease: Improving Global Outcomes) guidelines]) hyperparathyroidism.

Results: Incomplete surgical resolution of SHPT occurred in 23% of patients, with higher rates in hemodialysis (HD) patients (36%) than in peritoneal dialysis (PD) patients (20%, p=0.245). Preoperative alkaline phosphatase (ALP) was the only significant predictor of surgical success (B=-0.003, p=0.011). Hungry bone syndrome (HBS) was observed in 73.3% of PD patients and 52% of HD patients (p=0.143). Total parathyroidectomy showed a trend toward fewer failures than subtotal parathyroidectomy.

Conclusion: Preoperative ALP is a critical predictor of parathyroidectomy success in SHPT. Total parathyroidectomy may offer improved outcomes compared to subtotal parathyroidectomy. Individualized surgical planning is essential for CKD patients with SHPT.

Keywords: Alkaline phosphatase, chronic kidney disease, parathyroidectomy, renal replacement therapy, secondary hyperparathyroidism.

INTRODUCTION

Secondary hyperparathyroidism (SHPT) is a common complication of chronic kidney disease (CKD), resulting from disturbances in serum calcium, phosphate, and vitamin D homeostasis. Persistent imbalances in mineral metabolism lead to chronic stimulation of the parathyroid glands, causing glandular hyperplasia and excessive secretion of parathyroid hormone (PTH).[1] This dysregulation contributes to chronic kidney disease–mineral and bone disorder (CKD-MBD), a systemic condition linked to decreased quality of life and increased cardiovascular morbidity and mortality in CKD patients.[2] While initial treatment typically involves medical therapies—such as phosphate binders, vitamin D analogs, and calcimimetics—parathyroidectomy remains the definitive intervention for cases unresponsive to conservative management.[3]

Parathyroidectomy—performed either as a subtotal resection or as a total parathyroidectomy with autotransplantation—effectively lowers PTH levels and mitigates complications associated with SHPT.[4] The choice of surgical approach is influenced by various factors, including patient-specific characteristics and surgeon expertise. Subtotal parathyroidectomy involves removal of most parathyroid tissue, leaving a small remnant to maintain parathyroid function and reduce the risk of hypoparathyroidism. In contrast, total parathyroidectomy removes all parathyroid tissue, typically relocating a portion to the forearm or another site to preserve hormone production while minimizing the risk of recurrence.[5] Each technique carries potential risks: subtotal parathyroidectomy may lead to persistent or recurrent hyperparathyroidism, while total parathyroidectomy is associated with postoperative hypocalcemia and an increased risk of hungry bone syndrome (HBS).[5]

Despite advances in SHPT treatment, the optimal personalized surgical approach and predictors of surgical success remain unclear. This study compares outcomes of subtotal and total parathyroidectomy in CKD patients undergoing renal replacement therapy (RRT), focusing on the potential influence of preoperative factors such as laboratory values, RRT modality, and surgical technique, with the aim of contributing to a better understanding of factors associated with surgical outcomes, thereby supporting clinical decision-making and improving the management of SHPT in CKD patients.

MATERIALS AND METHODS

Study Design and Ethical Approval

This retrospective cohort study included adult patients with chronic kidney disease receiving renal replacement therapy who underwent parathyroidectomy for secondary hyperparathyroidism (SHPT) at the Gazi University Faculty of Medicine between January 2000 and January 2023.

KEY MESSAGES

- Higher ALP Predicts Success: Elevated preoperative ALP levels were associated with a greater likelihood of surgical success in SHPT, suggesting a link with higher bone turnover.
- Surgical Technique Matters: Total parathyroidectomy with autotransplantation showed lower failure rates than subtotal procedures, especially in patients with lower ALP.
- Graft Location May Influence Outcome: A single failure in the total parathyroidectomy group with an antecubital graft raises questions about optimal graft site selection.

Ethical approval was obtained from the Institutional Review Board of the Gazi University Faculty of Medicine (Approval Date: 29.04.2025, Number: 2025-835). The study was conducted in accordance with the Declaration of Helsinki (2013 revision), and written informed consent was obtained from all participants.

Patient Selection

Inclusion criteria were: age ≥18 years, CKD stage 5 on RRT (hemodialysis or peritoneal dialysis), clinically and biochemically confirmed SHPT, and having undergone subtotal or total parathyroidectomy. Surgery was indicated based on symptoms as well as biochemical findings.

Exclusion criteria included incomplete medical records (i.e., <6 months of postoperative follow-up), a history of prior parathyroid surgery, or lack of informed consent.

Data Collection

Demographic and clinical data were collected from medical records, including age, sex, duration of RRT, and comorbidities (e.g., hypertension, coronary artery disease, diabetes mellitus). Preoperative laboratory values were recorded, including serum calcium, phosphate, alkaline phosphatase (ALP), and parathyroid hormone levels.

Surgical Procedures and Postoperative Management

All surgeries were performed using the lateral approach. Patients underwent either subtotal parathyroidectomy (removal of 2–3.5 parathyroid glands) or total parathyroidectomy with autotransplantation (all glands removed with autotransplantation into the sternocleidomastoid or antecubital region), based on surgeon preference. The number of excised glands and the autotransplantation site were recorded.

Postoperative treatment generally included calcium carbonate (2500 mg, equal to 1000 mg elemental calcium) three times daily, vitamin D3 (880 IU) three times daily, and calcitriol (1 µg) once daily. Treatment was adjusted based on calcium and phosphate levels.

Outcome Definitions and Follow-up

Postoperative outcomes were assessed through retrospective review of medical records with a minimum follow-up period of six months (including clinical notes, laboratory results, imaging reports, and pathological findings).

Primary outcomes (incomplete surgical resolution of SHPT) included:

a. Persistent SHPT, defined as failure to reduce PTH by ≥50% within one hour postoperatively, based on the Miami criterion, indicating immediate surgical failure.[6]

b. Recurrent SHPT, defined as a subsequent increase in PTH levels to >2–9 times the upper limit of normal after an initially successful surgery, observed at or beyond six months postoperatively, in accordance with KDIGO (Kidney Disease: Improving Global Outcomes) guidelines.[7]

Secondary outcomes included:

a. Hungry bone syndrome, identified by prolonged hypocalcemia requiring calcium supplementation.

b. Postoperative complications and histopathological findings.

Serum calcium, phosphate, ALP, and PTH levels were evaluated at the first postoperative hour and at subsequent intervals, as recorded during routine clinical follow-up visits (typically every three months). Surgical success, recurrence, and complications were extracted from these records.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics for Mac, version 25.0 (IBM Corp., Armonk, NY, USA). Due to the limited sample size and non-normal data distribution, non-parametric tests (Mann–Whitney U for continuous variables and Chi-square test for categorical variables) were used. Continuous variables are presented as median (minimum–maximum). Categorical variables were presented as frequencies and percentages and compared using the Chi-square test or Fisher's exact test, as appropriate.

Multiple binary logistic regression analysis was used to assess the association between potential predictors and endpoints. Variables with $p<0.10$ in univariate analysis were included in the multiple binary logistic regression model. A backward stepwise elimination method was used for model selection. Model fit was assessed using the Hosmer–Lemeshow goodness-of-fit test, and discriminatory ability was evaluated using the area under the receiver operating characteristic (ROC) curve.

Multicollinearity among independent variables was evaluated using correlation matrices and variance inflation factors (VIF). A p-value <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics

The study included 65 adult CKD patients receiving RRT, with a median age of 51 years (range: 18.0–78.0). The median RRT duration was 13 months (range: 6–84). Fifty patients (76.9%) were on hemodialysis (HD) and 15 (23.1%) on peritoneal dialysis (PD). There were no significant differences between the HD and PD groups regarding gender (HD: 52% female; PD: 66.7% female, p=0.330), hypertension (70.8% vs. 66.7%, p=0.759), coronary artery disease (12.5% vs. 6.7%, p=0.530), or diabetes mellitus (6.3% vs. 0%, p=0.321).

The leading causes of CKD were hypertension (HD: 26%; PD: 46.7%) and glomerulonephritis (HD: 10%; PD: 26.7%). Preoperative laboratory parameters are summarized in Table 1.

Surgical Characteristics

All patients had clinical and laboratory findings consistent with SHPT prior to surgery. In evaluating preoperative characteristics, it was observed that some patients had serum calcium levels within target ranges but exhibited markedly elevated PTH levels. In other cases, patients had PTH levels near the upper limit of KDIGO recommendations but persistent, treatment-resistant hypercalcemia. In such scenarios, surgical decisions were guided not only by laboratory values but also by clinical symptoms and treatment response. Additionally, during the earlier years of the study period, limited access to calcimimetics and vitamin D monitoring may have influenced both the timing and the clinical thresholds for surgical referral. Fifty-five patients (84.6%) underwent subtotal parathyroidectomy, and 10 (15.4%) underwent total parathyroidectomy with autotransplantation (HD: 16%; PD: 13.3%; p=0.802). Autotransplantation was performed into the sternocleidomastoid muscle in seven patients and into the antecubital region in three (HD: 6.7%; PD: 4.0%; p=0.782). The number of excised glands did not significantly differ between HD and PD groups (p=0.535).

Among subtotal parathyroidectomy cases, the number of glands excised was as follows: 2 glands in 5 patients, 2.5 glands in 1 patient, 3 glands in 28 patients, and 3.5 glands in 2 patients. Pathology revealed one adenoma and one carcinoma, both

Table 1. Laboratory parameters of the study population

	Whole study group (n=65) Median (Min–Max)	HD group (n=50) Median (Min–Max)	PD group (n=15) Median (Min–Max)	p
BUN (mg/dL)	37 (13–90)	34 (13–82)	50 (20–90)	0.008
Creatinine (mg/dL)	6.24 (2.00–12.41)	5.97 (2.31–10.31)	7.56 (2.65–12.41)	0.005
Uric acid (mg/dL)	4.49 (1.12–7.50)	3.70 (1.10–7.00)	5.37 (1.80–7.50)	<0.001
Sodium (mEq/L)	137 (130–144)	137 (130–143)	135 (130–144)	0.021
Potassium (mEq/L)	4.40 (3.00–6.70)	4.50 (3.20–6.70)	4.50 (3.00–5.28)	0.178
Hemoglobin (g/dL)	11.10 (6.70–16.40)	11.50 (6.90–15.40)	8.90 (6.70–16.40)	0.030
Ferritin (ml/ng)	449 (35–1452)	425 (35–1452)	563 (447–983)	0.218
Calcium (mg/dL)	9.80 (7.20–12.06)	10.00 (7.80–12.06)	8.54 (7.20–11.30)	0.001
Phosphorus (mg/dL)	5.10 (2.59–8.80)	5.50 (2.70–8.80)	4.70 (2.59–7.63)	0.789
PTH (pg/mL)	1840 (291–4402)	1900 (291–4402)	1483 (599–4024)	0.388
ALP (IU/ml)	438 (84–2465)	351 (84–2465)	676 (101–2163)	0.150
Albumin (g/L)	4.10 (2.47–5.70)	4.10 (2.47–5.70)	3.60 (2.51–4.30)	0.002
CRP (mg/L)	5.40 (1.59–69.00)	4.10 (1.00–69.00)	5.40 (3.73–39.00)	0.881

P-values were calculated using the Mann–Whitney U Test for continuous variables and either Fisher's Exact Test or Pearson's Chi-Square Test for categorical variables, as appropriate. A p-value <0.05 was considered statistically significant. ALP: Alkaline phosphatase; BUN: Blood urea nitrogen; CRP: C-reactive protein; PTH: Parathyroid hormone; Min: Minimum; Max: Maximum.

Table 2. Demographics and clinical characteristics of the study population according to incomplete surgical resolution of SHPT

	Patients with incomplete surgical resolution of SHPT (n=21)	Patients with surgical success (n=44)	p
Age (years), Median (min–max)	51 (24–78)	46 (18–77)	0.811
Male (n (%))	9 (45%)	20 (45.45%)	0.844
Peritoneal dialysis (n (%))	3 (14.29%)	12 (27.27%)	0.245
RRT duration (months), Median (min–max)	15 (6–32)	13 (6–84)	0.610
BUN (mg/dL), Median (min–max)	34 (14–71)	37 (13–90)	0.110
Creatinine (mg/dL), Median (min–max)	5.79 (2.65–12.41)	6.75 (2.00–12.40)	0.250
Uric acid (mg/dL), Median (min–max)	3.30 (1.10–6.30)	4.60 (1.20–7.50)	0.131
Sodium (mEq/L), Median (min–max)	138 (135–142)	138 (130–144)	0.777
Potassium (mEq/L), Median (min–max)	4.40 (3.20–6.40)	4.59 (3.00–6.70)	0.817
Hemoglobin (g/dL), Median (min–max)	11.75 (6.70–16.40)	11.10 (6.90–15.40)	0.469
Ferritin (ng/mL), Median (min–max)	437 (35–964)	568 (132–1452)	0.292
Calcium (mg/dL), Median (min–max)	10.10 (7.50–12.06)	9.75 (7.20–11.70)	0.474
Phosphorus (mg/dL), Median (min–max)	4.50 (2.59–7.32)	5.35 (3.05–8.80)	0.190
PTH (pg/mL), Median (min–max)	1796 (700–3789)	1940 (291–4402)	0.721
ALP (IU/ml), Median (min–max)	262 (102–1163)	577 (84–2465)	0.033
Albumin (g/L), Median (min–max)	4.10 (2.47–5.70)	4.00 (3.10–5.20)	0.335
CRP (mg/L), Median (min–max)	3.00 (1.47–69.00)	9.75 (1.00–69.00)	0.160

P-values were calculated using the Mann–Whitney U Test for continuous variables and either Fisher's Exact Test or Pearson's Chi-Square Test for categorical variables, as appropriate. A p-value <0.05 was considered statistically significant. ALP: Alkaline phosphatase; BUN: Blood urea nitrogen; CRP: C-reactive protein; DM: Diabetes mellitus; HT: Hypertension; PTH: Parathyroid hormone; RRT: Renal replacement therapy; SHPT: Secondary hyperparathyroidism; Min: Minimum; Max: Maximum.

Table 3. Demographics and clinical characteristics of the subtotal parathyroidectomy group according to incomplete surgical resolution of SHPT

	Patients with incomplete surgical resolution of SHPT (n=20)	Patients with surgical success (n=35)	p
Age (years), Median (min–max)	51 (24–78)	43 (18–77)	0.446
Male, n (%)	9 (45%)	14 (40%)	0.718
Peritoneal dialysis, n (%)	3 (15%)	10 (28.57%)	0.254
RRT duration (months), Median (min–max)	15 (6–32)	13 (6–25)	0.456
BUN (mg/dL), Median (min–max)	35 (14–71)	38 (13–90)	0.183
Creatinine (mg/dL), Median (min–max)	5.88 (2.65–12.41)	6.26 (2.00–12.24)	0.694
Uric acid (mg/dL), Median (min–max)	3.95 (1.10–6.30)	4.60 (1.20–7.50)	0.203
Sodium (mEq/L), Median (min–max)	138 (135–142)	138 (130–144)	0.692
Potassium (mEq/L), Median (min–max)	4.45 (3.20–6.40)	4.50 (3.00–6.70)	0.759
Hemoglobin (g/dL), Median (min–max)	11.90 (6.70–16.40)	10.70 (6.90–15.40)	0.415
Ferritin (ng/mL), Median (min–max)	425 (35–824)	510 (132–1452)	0.257
Calcium (mg/dL), Median (min–max)	10.05 (7.50–12.06)	9.70 (7.56–11.70)	0.416
Phosphorus (mg/dL), Median (min–max)	4.50 (2.59–7.32)	5.40 (3.10–8.80)	0.177
PTH (pg/mL), Median (min–max)	1665 (700–3789)	1999 (599–4402)	0.525
ALP (IU/ml), Median (min–max)	235 (102–1163)	744 (84–2465)	0.003
Albumin (g/L), Median (min–max)	3.95 (3.10–5.20)	4.10 (2.47–5.10)	0.322
CRP (mg/L), Median (min–max)	3.50 (2.20–69.00)	12.65 (1.00–69.00)	0.395
Surgically removed glands, n (%)			0.319
2	3 (15%)	2 (5.7%)	
2+1 partial	1 (5%)	0 (0%)	
3	10 (50%)	18 (51.4%)	
3+1 partial	6 (30%)	15 (42.9%)	

P-values were calculated using the Mann–Whitney U Test for continuous variables and either Fisher's Exact Test or Pearson's Chi-Square Test for categorical variables, as appropriate. A p-value <0.05 was considered statistically significant. ALP: Alkaline phosphatase; BUN: Blood urea nitrogen; CRP: C-reactive protein; DM: Diabetes mellitus; HT: Hypertension; PTH: Parathyroid hormone; RRT: Renal replacement therapy; SHPT: Secondary hyperparathyroidism; Min: Minimum; Max: Maximum.

in HD patients. Concurrent thyroidectomy was performed in eight HD patients. Two patients experienced vocal cord injury.

Postoperative Outcomes

Hungry bone syndrome occurred in 26 HD patients (52%) and 11 PD patients (73.3%), with no statistically significant difference (p=0.143). The incidence of HBS did not differ significantly by surgery type (subtotal: 58.2%; total: 50.0%; p=0.631).

The median follow-up was 42 months (range: 6–155). Incomplete surgical resolution of SHPT occurred in 36% of HD and 20% of PD patients (p=0.245). Persistent hyperparathyroidism was observed in 32% of HD and 20% of PD patients (p=0.370). Recurrence of elevated PTH occurred in two HD patients (7.7%) and in none of the PD patients (p=0.344). All cases of persistent PTH elevation occurred in the subtotal parathyroidectomy group. Recurrence was seen in one patient from each surgical group (p=0.316).

Predictors of Incomplete Surgical Resolution of SHPT

When the study population was stratified by surgical success, only preoperative ALP levels were significantly associated with outcomes, while no significant differences were observed for RRT modality, gender, age, RRT duration, or other laboratory values (Table 2).

In the subtotal parathyroidectomy group, incomplete surgical resolution of SHPT was not associated with gender, type of renal replacement therapy, or the number of glands excised. However, low serum alkaline phosphatase levels were significantly associated with incomplete surgical resolution of SHPT (Table 3, Fig. 1).

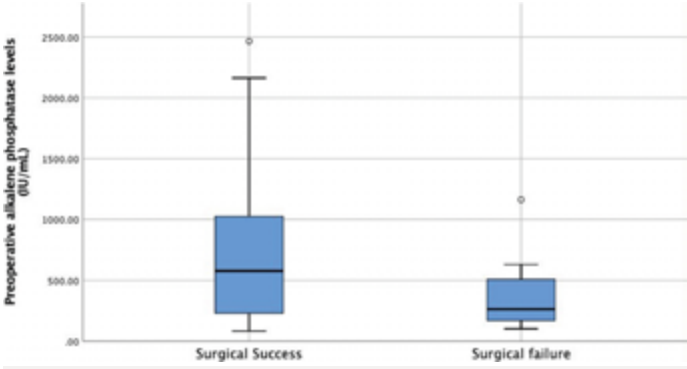

Figure 1. Preoperative alkaline phosphatase (ALP) levels among patients with successful and incomplete surgical resolution of secondary hyperparathyroidism. Boxplots represent the median (horizontal line), interquartile range (box), and full range (whiskers). Preoperative alkaline phosphatase levels were significantly higher in patients with successful surgery (p=0.033).

In the multiple binary logistic regression analysis, preoperative ALP levels (expressed per 100 IU/L) remained the only statistically significant predictor of incomplete surgical resolution of SHPT (B=-0.199, p=0.019; odds ratio [OR]=0.819; 95% confidence interval [CI]: 0.694–0.968). This indicates that for every 100 IU/L increase in ALP, the odds of incomplete surgical resolution of SHPT decreased by approximately 18%. Other variables, such as RRT modality and the number of surgically removed glands (when entered as a categorical variable), did not show a statistically significant association with surgical outcomes.

DISCUSSION

The findings of this study highlight the significant role of preoperative ALP levels as a predictor of surgical success in CKD patients with SHPT. Elevated ALP levels, indicative of increased bone turnover, were found to be associated with a lower risk of incomplete surgical resolution of SHPT. This aligns with existing literature, which has consistently pointed to ALP as a crucial marker for disease severity and its impact on parathyroidectomy outcomes. Elevated ALP levels reflect the extent of bone involvement in SHPT, and their predictive value suggests that more severe bone turnover may warrant more aggressive surgical management.

While our findings suggest a link between preoperative ALP levels and both surgical success and SHPT recurrence, the literature still lacks a clear consensus regarding the risk factors for persistent PTH elevation or postoperative SHPT recurrence. Previous studies, particularly those focusing on primary hyperparathyroidism, have suggested that factors such as vitamin D deficiency and HBS are associated with increased postoperative PTH levels.[8,9] Although this study did not explore the role of vitamin D or renal function in depth, these elements warrant further investigation in future research to better understand the causes of postoperative SHPT persistence.

In terms of surgical outcomes, our study revealed a higher failure rate in the subtotal parathyroidectomy group compared to the total parathyroidectomy group. This finding supports existing evidence suggesting that subtotal parathyroidectomy may leave behind hyperfunctioning parathyroid tissue, leading to persistent or recurrent SHPT. These patients are at higher risk of requiring further intervention, and our results emphasize that subtotal parathyroidectomy, though less invasive, may not always provide long-term disease control.[10] In contrast, total parathyroidectomy with autotransplantation, while associated with a greater risk of complications such as hypocalcemia, has been shown to offer more definitive control of SHPT and lower rates of recurrence.[10] In particular, among patients with lower preoperative ALP levels, total parathyroidectomy may yield better outcomes, underscoring the importance of tailoring the surgical approach based on biochemical markers.

Hungry bone syndrome was observed to be more prevalent in patients on PD compared to those on HD, with rates of 73.33% and 52%, respectively. Although this difference did not reach statistical significance, it highlights an important clinical observation: compared to HD patients, those on PD may be at increased risk of developing hungry bone syndrome following parathyroidectomy, potentially due to differences in bone metabolism and calcium-phosphate handling.[11] PD has been associated with more continuous but lower-efficiency phosphate and calcium removal, which may lead to higher baseline bone turnover and impaired skeletal responsiveness to parathyroid hormone. These alterations could predispose patients to abrupt post-operative calcium shifts. Although direct comparisons are limited, at least one retrospective cohort by Yeh et al.[12] reported a high incidence of HBS among PD patients after parathyroidectomy (PTX) (71.2%), suggesting a possible trend worth further investigation.

Although RRT modality did not significantly influence overall surgical success, HD patients in this study had a higher rate of persistent hyperparathyroidism, adenoma, and carcinoma, compared to PD patients. These findings may reflect the greater disease burden in HD patients, consistent with prior studies indicating that long-term HD patients may have more advanced SHPT due to prolonged exposure to uremia and mineral bone disorders.[13] Moreover, the presence of concurrent thyroidectomy in some HD patients further complicates the

surgical landscape, as thyroid dysfunction may exacerbate challenges in managing SHPT.

We identified a single case of incomplete surgical resolution of SHPT in the total parathyroidectomy group, which occurred in a patient who underwent autotransplantation to the antecubital area. While this observation does not allow for generalization, it raises questions about the potential influence of graft location on surgical outcomes. Given that the antecubital site is commonly selected for ease of access in re-exploration, further studies comparing outcomes between different autotransplantation sites (e.g., forearm vs. sternocleidomastoid muscle) are warranted.

This study's retrospective nature and relatively small sample size limit the generalizability of its findings. Although we identified key predictors of surgical success, the limited number of patients and the single-center design restrict the broader applicability of these results. The absence of statistical significance in certain subgroup comparisons may reflect insufficient statistical power due to the small number of patients, particularly in the total parathyroidectomy group, and thus findings should be interpreted with caution. Also, preoperative vitamin D levels were not consistently available for all patients due to the retrospective nature of data collection. This limited our ability to evaluate the potential impact of vitamin D status on surgical outcomes. Furthermore, given the long-term follow-up in this cohort, there may have been variations in surgical technique and postoperative care over time, which could have influenced outcomes. This temporal heterogeneity represents a potential confounder that may have influenced the results. Future prospective multicenter studies with larger, more diverse cohorts are necessary to validate these findings and refine surgical strategies. Specifically, a randomized controlled trial comparing subtotal and total parathyroidectomy would provide more robust data on the optimal surgical approach for SHPT in CKD patients.

CONCLUSION

In conclusion, this study suggests that preoperative low ALP levels serve as a critical determinant of parathyroidectomy success in CKD patients with SHPT. Total parathyroidectomy, despite its associated risks, may offer superior outcomes compared to subtotal parathyroidectomy, particularly for patients with lower ALP levels. These findings underscore the importance of personalized treatment strategies, considering both biochemical markers and patient-specific factors such as RRT modality and disease severity. Moreover, the study highlights the need for more extensive research, particularly prospective multicenter trials, to further refine surgical techniques and improve outcomes in the management of SHPT in CKD patients.

Ethics Committee Approval: The Gazi University Ethics Committee granted approval for this study (date: 29.04.2025, number: 2025-835).

Informed Consent: Written informed consent was obtained from the participants.

Conflict of Interest: The authors have no conflicts of interest to declare.

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