Original Article

Branch Ligation versus Truncal Ligation of Inferior Thyroid Arteries in Total Thyroidectomy: Impact on Transient Hypocalcemia

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Abstract

Objective: Following a complete thyroidectomy, transient hypocalcemia is a frequent side effect. The incidence of transitory hypocalcemia following inferior thyroid artery (ITA) branch ligation and truncal ligation was examined in this study. This study compares the two techniques in terms of their effect on calcium levels.

Methods: The ninety-four patients were assigned to truncal ligation and branch ligation groups according to the surgeon's practice. Records were kept of preoperative calcium, intraoperative and postoperative variables, and parathyroid hormone (PTH). Serum calcium and PTH levels were measured one, two, and three months following surgery. The results were evaluated using chi-square, t-, and logistic regression tests.

Results: The truncal ligation group experienced postoperative hypocalcemia considerably more frequently (40.4%) than the branch ligation group (0%; $p < 0.001$) on postoperative day 1. The truncal ligation group had consistently reduced postoperative calcium and PTH levels at all time points. Truncal ligation was validated as a significant predictor of hypocalcemia by multivariate analysis (OR = 0.007, p = 0.009).

Conclusions: Transient hypocalcemia is considerably less common when the ITAs are branch-ligated following complete thyroidectomy. These findings emphasize the importance of careful vascular preservation for preserving parathyroid function.

Keywords: Thyroidectomy; Hypocalcemia; Thyroid Diseases; Parathyroid Hormone, Hypoparathyroidism: Adverse Effects.

Introduction

Thyroid tumors, Graves' disease, and multinodular goiter can all be treated with total thyroidectomy. Hypocalcemia is the most common post-surgery complication, affecting up to 30% of patients.[1] The main reasons are either ischemic damage or unintentional removal of the parathyroid glands, which are necessary to keep calcium levels within normal limits.[2] The parathyroid glands receive their main vascular supply from the inferior thyroid arteries (ITAs). Following surgery, parathyroid function is directly impacted by intervention on these arteries.[3]

Because it facilitates thyroid mobility and reduces intraoperative hemorrhage, truncal ligation of the inferior thyroid arteries at their origin has long been the preferred procedure. Numerous studies have shown that truncal ligation may obstruct blood flow to the parathyroid glands, which could lead to temporary or chronic hypocalcemia.[4] On the other hand, branch ligation is the best way to maintain parathyroid vascularization and stop bleeding at the same time.[5] The distal branches of the ITA near the thyroid capsule are the only ones that are ligated during this procedure. According to a recent meta-analysis, patients who had branch ligation had a much lower incidence of hypocalcemia than those who had truncal ligation.[6]

The likelihood of hypocalcemia may be influenced by additional factors that arise during surgery. Large goiters and inadequate vitamin D before surgery are known to affect calcium levels after surgery,[7] and complications involving the parathyroid have been linked to central compartment clearance, prolonged surgical times, and extensive nodal dissection.[8] It has been shown that measuring intact parathyroid hormone (PTH) levels

soon after surgery is a useful way to identify hypocalcemia, allowing doctors to promptly administer calcium and vitamin D.

Despite mounting evidence of the procedure's effectiveness, there are few high-quality randomized controlled trials comparing branch ligation to truncal ligation. Through careful monitoring of biochemical levels over three months, this study aimed to ascertain the frequency of transient hypocalcemia linked to two procedures in total thyroidectomy. By clarifying the mechanism of the vascular ligation technique, this study seeks to offer evidence-based suggestions for improving the outcomes of thyroidectomy procedures.

Materials And Methods

This study was a quasi-experimental study that used two different surgical techniques, truncal ligation versus branch ligation of the ITAs, to investigate the incidence of temporary hypocalcemia after total thyroidectomy. The study was carried out in the ENT division of Benazir Bhutto Hospital in Rawalpindi. It started in December 2023 and ended in May 2025. The sample size was calculated based on the incidence of transient hypocalcemia reported in a previous study (22.9% in the truncal ligation group vs. 3.1% in the branch ligation group). Using a two-proportion comparison formula with a 95% confidence level ($\alpha = 0.05$) and 80% power ($1 - \beta = 0.8$), the required sample size was determined as 42 participants per group. To account for a 10% dropout rate, the final sample size was adjusted to 47 participants per group, totaling 94 participants. Inclusion Criteria were adults (≥18 years) undergoing total thyroidectomy for benign or malignant thyroid disease, normal preoperative serum calcium and parathyroid hormone (PTH) levels, and patients with no history of previous neck surgery or radiation. While exclusion criteria were patients undergoing subtotal, near-total, or lobectomy procedures, or having preexisting parathyroid dysfunction, or suffering from chronic kidney disease or conditions affecting calcium metabolism (such as diabetes or osteoporosis), with extremes of BMI, and low preoperative vitamin D levels, comorbidities (Diabetes, Kidney Disease, Osteoporosis).

Surgical procedure had the following important points of note (Illustrated in Figure 3):

1. Truncal Ligation Group: The ITAs were ligated at their origin from the subclavian artery.
2. Branch Ligation Group: The ITAs were dissected along the thyroid capsule, and only their terminal branches were ligated to preserve blood supply to the parathyroid glands.
3. Recurrent laryngeal nerves and parathyroid glands were identified and preserved in both groups.

Comparable surgeon level, and no autotransplantation of parathyroid glands was done, only preservation. The procedure performed was at the surgeon's preference.

Data were collected at multiple defined time points to ensure comprehensive evaluation of perioperative and postoperative parameters. During the preoperative assessment, serum calcium, parathyroid hormone (PTH), albumin, and thyroid function tests were measured, along with the recording of demographic data and the clinical diagnosis of each patient. Intraoperative variables included the duration of the surgery (operative time), estimated blood loss, and any immediate complications encountered. Postoperative monitoring focused on the measurement of serum calcium and PTH levels on postoperative day 2, as well as at 1 month and 3 months following the procedure. Additionally, the need for exogenous calcium and vitamin D supplementation during the postoperative period was documented to assess calcium homeostasis and recovery.

Primary outcome was the incidence of transient hypocalcemia, which is characterized by serum calcium levels below 8.0 mg/dL, with or without symptoms, that resolves in up to six months and necessitates calcium supplementation.[9] Secondary outcomes were serum calcium and PTH levels over follow-up, need for prolonged calcium and vitamin D supplementation, and the number of parathyroid glands identified & preserved.

For continuous variables, descriptive statistics were expressed as mean ± standard deviation (SD), and for categorical variables, frequency with percentage. Transient hypocalcemia and nerve damage were analyzed as categorical outcomes using the Chi-square test or Fisher's exact test for group comparison, while continuous variables like serum calcium and PTH levels were analyzed using independent t-tests or Mann-Whitney U tests. To measure the size of differences, effect sizes were computed using Cohen's d for continuous outcomes and risk ratios (RR) or odds ratios (OR) for categorical outcomes. To account for potential confounding factors like age, thyroid disease, and gland size, we used logistic regression for multivariate analysis. SPSS Version 26 was used for all analyses. A p-value of less than 0.05 was considered statistically significant in the analysis.

The study was conducted in accordance with ethical standards and principles. Ethics committee approval was obtained before the commencement of research. Informed consent was acquired from all participants involved in the study. The research was conducted with respect for participant privacy, confidentiality, and autonomy.

Results

A total of 94 patients were included in the study, with an equal distribution between the truncal ligation group (n = 47) and the branch ligation group (n = 47). The mean age of the participants was comparable between the two groups (43.5 ± 11.4 vs. 43.3 ± 11.2 years, $p = 0.91$). The gender distribution was also similar (Male: 12.8% vs. 14.9%, $p = 0.78$). There were no significant differences in baseline preoperative calcium (9.63 ± 0.40 vs. 9.62 ± 0.39 mg/dL, $p = 0.95$) and preoperative PTH levels (41.52 ± 4.62 vs. 41.53 ± 4.61 pg/mL, $p = 0.98$) between the groups (Table 1).

Table 1: Baseline Characteristics of the study population

Variable	Truncal Ligation (n = 47)	Branch Ligation (n = 47)	p-value
Age (years), Mean ± SD	43.5 ± 11.4	43.3 ± 11.2	0.91
Gender (Male), n (%)	6 (12.8%)	7 (14.9%)	0.78
PreOp Calcium (mg/dL)	9.63 ± 0.40	9.62 ± 0.39	0.95
PreOp PTH (pg/mL)	41.52 ± 4.62	41.53 ± 4.61	0.98
Parathyroid Glands Preserved	1.8 ± 0.6	1.7 ± 0.7	0.89

Postoperative hypocalcemia was significantly more frequent in the truncal ligation group compared to the branch ligation group. On postoperative day 1, 40.4% of patients in the truncal ligation group developed hypocalcemia, whereas none of the patients in the branch ligation group were affected ($p < 0.001$). This difference persisted at 1 month and 3 months postoperatively, with hypocalcemia rates remaining significantly higher in the truncal ligation group ($p < 0.001$) (Table 2).

Table 2: Hypocalcemia Rates (Chi-Square Test)

Group	Hypocalcemia (Yes)	No Hypocalcemia	Total	p-value
Truncal Ligation	19 (40.4%)	28 (59.6%)	47	**p < 0.001**
Branch Ligation	0 (0%)	47 (100%)	47	

The postoperative calcium and PTH levels exhibited significant differences between the two groups over the follow-up period. On postoperative day 1, calcium levels were significantly lower in the truncal ligation group compared to the branch ligation group (8.02 ± 0.53 vs. 8.77 ± 0.39 mg/dL, $p < 0.001$). This trend persisted at 1 month (8.05 ± 0.69 vs. 8.89 ± 0.39 mg/dL, $p < 0.001$) and 3 months postoperatively (8.25 ± 0.69 vs. 9.00 ± 0.39 mg/dL, $p < 0.001$) (Figure 1).

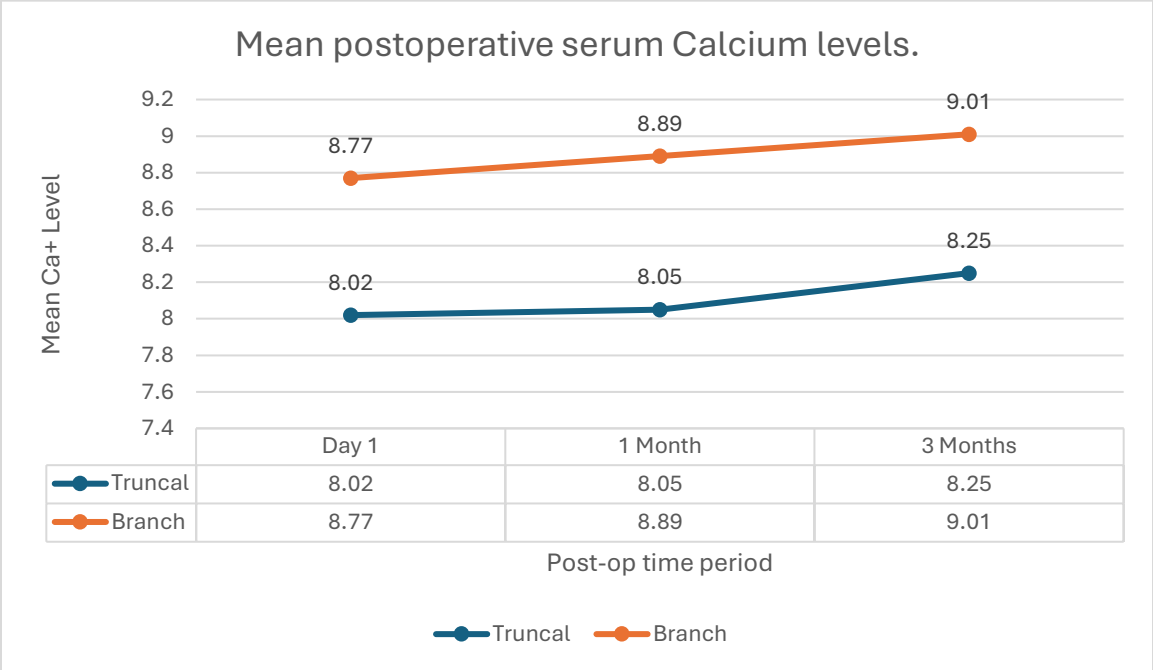

Figure 1: Trends of postoperative calcium levels for the two groups over the postoperative follow-up period.

Similarly, PTH levels were significantly lower in the truncal ligation group compared to the branch ligation group at all postoperative time points. On postoperative day 1, PTH levels were 36.82 ± 2.93 pg/mL in the truncal ligation group compared to 42.63 ± 3.21 pg/mL in the branch ligation group ($p < 0.001$). This difference persisted at 1 month (39.81 ± 3.01 vs. 44.80 ± 3.22 pg/mL, $p < 0.001$) and 3 months postoperatively (41.67 ± 3.17 vs. 46.92 ± 3.33 pg/mL, $p < 0.001$) (Figure 2).

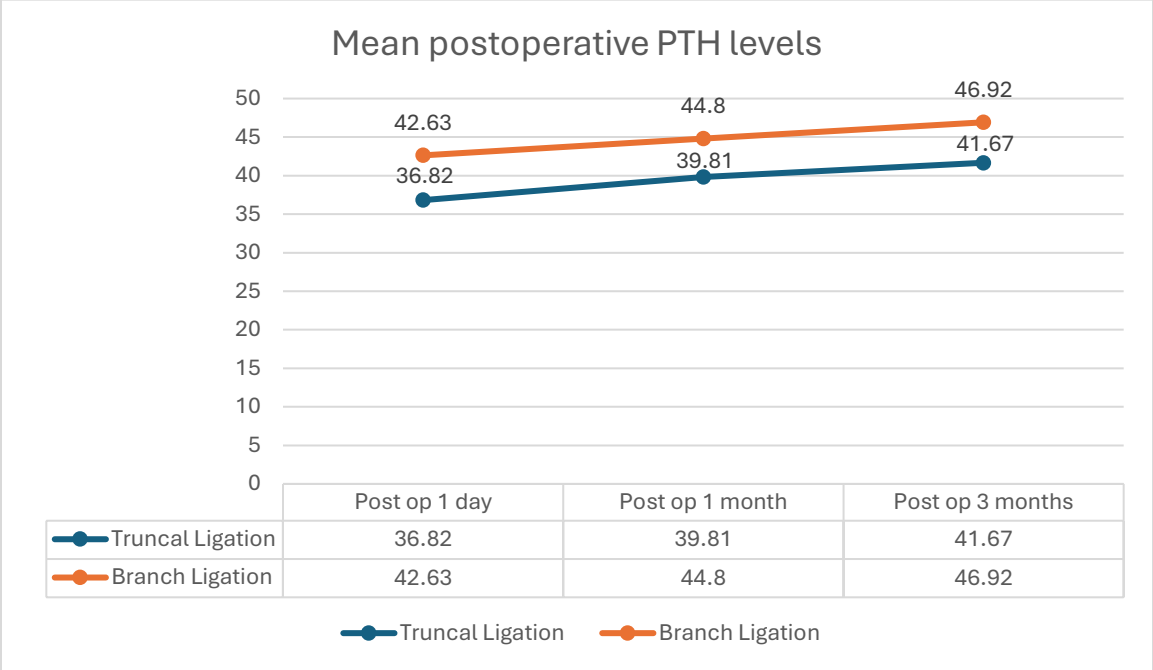

Figure 2: Trends of postoperative PTH levels for the two groups over the postoperative follow-up period.

To determine the independent predictors of postoperative hypocalcemia, a multivariate logistic regression analysis was performed, including key preoperative and intraoperative variables (Table 3).

Table 3: Multivariate Logistic Regression Analysis for Predictors of Postoperative Hypocalcemia

Variable	B	S.E.	Wald	df	Sig. (p-value)	OR (95% CI)
Type of Surgery (Truncal vs. Branch)	-4.916	1.890	6.768	1	**0.009**	**0.007 (0.000 – 0.262)**
Preoperative Calcium	-1.965	1.390	1.997	1	0.158	0.140 (0.007 – 2.897)
Postoperative Calcium (Day 1)	-0.032	0.815	0.002	1	0.969	0.969 (0.188 – 5.005)
Preoperative PTH	0.196	0.094	4.345	1	**0.037**	**1.216 (1.012 – 1.462)**
Postoperative PTH (Day 1)	0.297	0.141	4.415	1	**0.036**	**1.346 (1.019 – 1.780)**
Number of Preserved Parathyroid Glands	0.019	0.626	0.001	1	0.976	1.019 (0.296 – 3.512)
Constant	3.187	12.141	0.069	1	0.793	24.209

The analysis identified the type of surgery (truncal vs. branch ligation) as a significant predictor of postoperative hypocalcemia. Patients undergoing truncal ligation had significantly higher odds of developing hypocalcemia compared to those who underwent branch ligation (OR = 0.007, 95% Confidence Interval [CI]: 0.000 – 0.262, p = 0.009). This suggests that truncal ligation is strongly associated with an increased risk of transient hypocalcemia.

Preoperative calcium levels did not significantly predict postoperative hypocalcemia (OR = 0.140, 95% CI: 0.007 – 2.897, p = 0.158), indicating that baseline calcium levels may not be a decisive factor in hypocalcemia risk. Similarly, postoperative calcium levels on day 1 did not emerge as a significant predictor (OR = 0.969, 95% CI: 0.188 – 5.005, p = 0.969).

However, both preoperative PTH levels and postoperative PTH levels on day 1 were significantly associated with postoperative hypocalcemia risk. Higher preoperative PTH levels were found to be protective against hypocalcemia, with an OR of 1.216 (95% CI: 1.012 – 1.462, p = 0.037). Similarly, lower postoperative PTH levels on day 1 were significantly associated with increased hypocalcemia risk (OR = 1.346, 95% CI: 1.019 – 1.780, p = 0.036).

Interestingly, the number of preserved parathyroid glands did not significantly affect the risk of hypocalcemia (OR = 1.019, 95% CI: 0.296 – 3.512, p = 0.976), suggesting that while parathyroid preservation remains an important surgical

principle, other factors such as the extent of devascularization and intraoperative trauma may play a larger role in postoperative calcium homeostasis.

These findings highlight that truncal ligation significantly increases the risk of transient hypocalcemia, and early postoperative PTH levels may serve as a useful predictor for identifying patients at risk. This emphasizes the importance of meticulous parathyroid preservation and postoperative monitoring in patients undergoing total thyroidectomy.

Discussion

In comparison to truncal ligation, branch ligation of the ITAs considerably lowers the frequency of temporary postoperative hypocalcemia, according to this study. These results are consistent with previous research that highlights how crucial it is to maintain parathyroid perfusion following thyroidectomy.[5]

The preservation of vascular supply in preserving parathyroid function is of vital importance.[10] As illustrated in **Figure 3**, the anatomical distinction between these two surgical techniques is central to maintaining parathyroid integrity. Truncal ligation involves securing the ITA at its main trunk, a method that can inadvertently lead to global ischemia of the parathyroid glands by obstructing their primary vascular source. In contrast, branch ligation involves meticulous microdissection to ligate only the terminal branches directly on the thyroid capsule. This selective approach ensures that the blood supply to the parathyroid glands remains intact, explaining the significantly lower incidence of hypocalcemia and the more stable postoperative PTH levels observed in our branch ligation group.

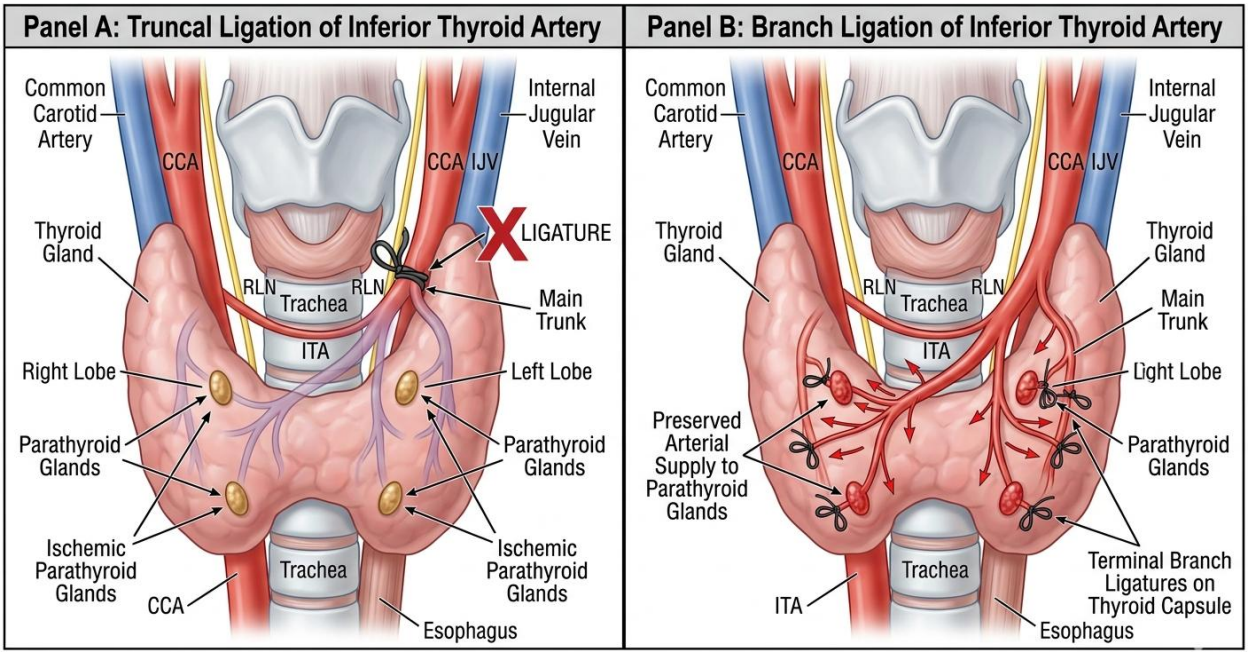

Figure 3: Comparison of Vascular Ligation Techniques during Total Thyroidectomy

El-Din et al. found that 24% of patients receiving truncal ligation had hypocalcemia, while only 8% of patients receiving selective ligation had this condition.[11] An even larger discrepancy was seen in our study: 40.4% in the group that underwent truncal ligation and 0% in the group that underwent branch ligation. This significant discrepancy supports the idea that careful preservation of the terminal branches could produce better results.

Patients with ITA trunk ligation had transient hypocalcemia rates of 28% and chronic hypocalcemia rates of 3.4%, according to a multicenter series by Thomusch et al. that examined 5,846 thyroidectomies.[12] Our results are somewhat different, most likely because patients with large goiters or extensive lymph node dissection, known risk factors, were not included in the analysis.[13] Permanent hypocalcemia did not develop in our group, indicating that uniform surgical technique and patient selection are important outcome predictors. Crucially, the most accurate biochemical predictor of hypocalcemia is generally agreed to be early postoperative parathyroid hormone (PTH) testing. According to Mattoo et al., the best cut-off values of Serum iPTH to predict hypocalcemia were found to be 4.28 pmol/l at 20 min post-total thyroidectomy with a sensitivity and specificity of 81.7% and 51%, respectively.[14]

The truncal ligation group in our study had considerably lower postoperative PTH, indicating its potential for targeted supplementation and early identification of at-risk individuals.

Singh et al. showed a significant difference in operation length comparing truncal and branch ligation procedures (mean operative time 45.6 vs. 63.6 minutes, $p < 0.001$), supporting some writers' claims that ligating the ITA trunk shortens the operating time.[15] Similar to our experience, branch ligation necessitated meticulous microdissection but did not significantly lengthen surgery. Furthermore, any slight increase in dissection time is justified by the better calcium results. The likelihood of hypocalcemia is influenced by vascular method as well as other variables such as vitamin D insufficiency, large gland size, and previous neck radiation. Regardless of the ligation technique, Celik et al. found that patients with retrosternal goiters or nodules greater than 40mm were more likely to have hypocalcemia.[16]

Whether routine parathyroid autotransplantation improves results is another factor to take into account. Selective autotransplantation of devascularized glands decreased permanent hypocalcemia according to a study by Qiu et al.[17] Our series, however, showed that meticulous branch ligation and preservation alone can be adequate, as no autotransplantation was needed. Our study's comparable rates of recurrent laryngeal nerve palsy across groups support the findings of Tian et al., who found that, when carried out by skilled surgeons, the vascular ligation method has no effect on the risk of nerve injury.[18] Lastly, branch ligation lowers the incidence of hypocalcemia by 55% when compared to truncal ligation in over 2,500 patients, according to a recent meta-analysis by Ahmed et al.[19] Our research backs up these findings and offers more proof to help direct surgical practice.

This study has several limitations that should be acknowledged. The quasi-experimental design, with group allocation based on surgeon preference rather than randomization, may introduce selection bias, although baseline characteristics were comparable between the truncal and branch ligation groups. The sample size of 94 patients, while adequate for detecting differences in hypocalcemia rates, limits the power to assess rarer outcomes such as permanent hypoparathyroidism or recurrent laryngeal nerve injury. Conducted at a single tertiary center in Rawalpindi, the findings may not generalize to diverse populations or settings with varying surgical expertise and resources. The 3-month follow-up period sufficiently captured early postoperative trends but may not fully delineate long-term resolution of hypocalcemia, as transient cases typically resolve within 6 months according to established guidelines. Additionally, exclusion of high-risk patients, such as those with retrosternal goiters or comorbidities, potentially underestimates complication rates in broader clinical contexts, and reliance on visual parathyroid identification without advanced imaging techniques like near-infrared autofluorescence may overlook subtle vascular compromise.

Future research should focus on large-scale, multicenter randomized controlled trials to mitigate biases and enhance generalizability, with extended follow-up periods of at least 6-12 months to distinguish transient from permanent hypocalcemia and evaluate long-term patient-reported outcomes, including quality of life. Incorporating advanced intraoperative tools, such as indocyanine green angiography or parathyroid autofluorescence, could provide objective assessments of vascular preservation and refine ligation techniques. Studies should also include high-risk cohorts, such as patients undergoing extensive central neck dissection or those with preoperative vitamin D deficiency, to better inform risk stratification. Furthermore, exploring the cost-effectiveness of branch ligation compared to truncal approaches, along with novel biomarkers or genetic factors influencing parathyroid resilience, may facilitate personalized surgical strategies and ultimately reduce postoperative morbidity in thyroidectomy procedures.

Conclusions

In addition to preserving similar operating times and low rates of recurrent laryngeal nerve damage, branch ligation of the inferior thyroid arteries during total thyroidectomy dramatically lowers the prevalence of temporary hypocalcemia. This method reduces the requirement for long-term calcium and vitamin D supplements while maintaining parathyroid vascularization. Targeted supplementation and prompt identification of individuals at risk for hypocalcemia are made possible by the combination of careful branch ligation and early postoperative parathyroid hormone testing. Branch ligation should be regarded as the recommended procedure in total thyroidectomy to maximize patient safety and surgical results, according to our findings and supporting data, with future studies focusing on randomized designs and advanced preservation techniques.

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