CROATIAN HEAD & NECK JOURNAL

The association of loupe magnification and hypocalcemia rates following total thyroidectomy: a single-surgeon retrospective cohort study

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Received: February 2, 2026
Accepted: March 18, 2026

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Aim To evaluate the association between the use of surgical loupe magnification and the rates of transient and permanent hypocalcemia following total thyroidectomy.

Methods This retrospective cohort study enrolled 340 patients who underwent total thyroidectomy between 2013 and 2024 at the Department of Otorhinolaryngology and Head and Neck Surgery, University Hospital Center Zagreb; all were operated on by a single surgeon. Patients were divided into those in whom the procedures were performed without surgical loupes (2013-2018, n=182) and those in whom the procedures were performed with loupes (2018-2024, n=158). Temporary hypocalcemia was defined as serum calcium <2.0 mmol/L resolving within 6 months, while permanent hypocalcemia persisted beyond 6 months. Univariate and multivariate logistic regressions were used to identify factors associated with hypocalcemia outcomes.

Results The use of surgical loupes was associated with significantly reduced hypocalcemia rates. Temporary hypocalcemia decreased from 50.0% in the non-loupe group to 32.9% in the loupe group (p=0.002), while permanent hypocalcemia decreased from 27.1% to 14.6% (p=0.004). In univariate analysis, loupe magnification was a significant protective factor for both temporary (odds ratio [OR] 0.49, 95% confidence interval [CI] 0.316-0.762) and permanent hypocalcemia (OR 0.45, 95% CI 0.259-0.782). In multivariate models, a reduced hypocalcemia risk was associated with loupe magnification, although collinearity with increasing surgical experience was observed.

Conclusion Loupe magnification during total thyroidectomy is associated with a clinically and statistically significant reduction in both transient and permanent postoperative hypocalcemia. As simple, low-cost, and widely available adjuncts, surgical loupes may contribute to an improved preservation of parathyroid function, particularly when integrated with increasing surgical experience.

INTRODUCTION

Total thyroidectomy is the standard surgical procedure for a wide spectrum of benign and malignant thyroid diseases (1). Most frequent complications include recurrent laryngeal nerve (RLN) injury and hypocalcemia due to hypoparathyroidism (2,3). The reported prevalence rates of postoperative hypocalcemia differ widely, primarily as a result of between-study differences in calcium cut-off values, definitions, case mix, follow-up duration, the timing of measurements, and definitions of "transient" versus "permanent" hypocalcemia (variably set around 6 months postoperatively) (4). Transient hypocalcemia occurs in 20% to 50% of patients, and permanent hypocalcemia in 1% to 10% (3,5,6). Post-thyroidectomy hypocalcemia is a consequence of transient or permanent hypoparathyroidism. It most commonly results from an inadvertent removal of the parathyroid gland or a mechanical injury to the parathyroid glands and/or their delicate vascular pedicles (7,8). Postoperative hypocalcemia clinically presents as perioral and/or acral paresthesias and tetany. More severe symptoms, including laryngospasms, seizures, and cardiac arrhythmias, may require intensive care treatment and prolonged intravenous calcium supplementation (2,7). Biochemical hypocalcemia is asymptomatic and more common but still necessitates supplementation therapy and monitoring (7). Risk factors for hypocalcemia after total thyroidectomy include female sex, autoimmune and malignant thyroid disease, large goiters, Graves' disease, central neck dissection, re-operative surgery, and low surgeon or institutional volume (7,9). Biochemical variables such as low preoperative calcium or vitamin D levels, as well as an early postoperative decline in parathyroid hormone (PTH), have also been associated with an increased risk and are increasingly used in prediction models and early-discharge algorithms (3,10). Post-thyroidectomy hypocalcemia not only causes severe symptoms, but also represents a clinical and economic burden; therefore, considerable effort is being directed at strategies to preserve parathyroid function (11,12). Current approaches include meticulous capsular dissection, systematic identification and preservation of all visible parathyroid glands, selective autotransplantation of devascularized glands, and the use of adjunctive technologies such as intraoperative PTH monitoring, indocyanine-green angiography, and autofluorescence imaging (8). Despite these measures, the reported rates of hypocalcemia remain substantial across series from high-volume centers. Furthermore, hypocalcemia affects the length of stay, readmission, and long-term morbidity after thyroid surgery, which underscores the need for further technical refinements (7). One of the simplest and most widely accessible techniques proposed to facilitate parathyroid and RLN preservation is optical magnification using surgical loupes. By enhancing visualization of small structures and fine vascular branches on the thyroid capsule, loupe-assisted thyroidectomy can make the dissection more accurate. Moreover, it can reduce inadvertent trauma to parathyroid glands and their blood supply. Several studies have examined the role of loupe magnification in reducing complications after thyroidectomy. Pata et al reported a significant reduction in inadvertent parathyroid removal and in both biochemical and clinical hypocalcemia with routine use of 2.5× loupes compared with unaided surgery (13). D'Orazi et al described their 10-year experience with loupe-assisted thyroidectomy in 782 patients, with low rates of permanent hypoparathyroidism, though the absence of a control group limits interpretation (14). Our study adds to this limited number of studies by comparing hypocalcemia outcomes between loupe and non-loupe thyroidectomy under uniform operative and postoperative conditions.

PATIENTS AND METHODS

We retrospectively reviewed the medical records of 340 patients who were operated on at the Department of Otorhinolaryngology and Head and Neck Surgery, University Hospital Center Zagreb, between 2013 and 2024. All patients underwent total thyroidectomy due to benign or malignant thyroid disease. Patients were divided into two groups based on the use of surgical loupes during surgery: from 2013-2018, the procedures were performed without loupes (n=182), while from 2018-2024, the procedures were performed with surgical loupes (n=158).

The analyzed variables included sex, age at the time of surgery, thyroid volume (in milliliters), histopathological findings (benign or malignant disease), and the occurrence of temporary and permanent postoperative hypocalcemia. Temporary postoperative hypocalcemia was defined as a transient decrease in calcium concentration (<2 mmol/L) after surgery that resolved within 6 months, while permanent hypocalcemia indicated persistent hypocalcemia >6 months after surgery (i.e., that which required long-term calcium and/or vitamin D supplementation). The patients were followed up after surgery for at least 6 months. Two patients for whom outcome data after 6 months were not available were excluded from the permanent hypocalcemia analysis. All operations were performed by the same surgeon, who by 2013, had already performed thyroid surgery for 5 years.

Statistical analysis

The normality of distribution of continuous variables was assessed using the Shapiro-Wilk test. Continuous variables are presented as mean ± standard deviation (SD) or as median and range. Categorical variables are presented as frequencies and percentages. Differences between groups in continuous variables were assessed using Welch's t-test (independent samples, not assuming equal variances) or the Mann-Whitney U test. Differences in categorical variables were assessed using the χ^2 test. Univariate logistic regression was performed for each predictor to identify factors associated with hypocalcemia outcomes. Multivariate logistic regression included all the significant predictors from the univariate analysis. P-values for coefficients in logistic regression models were determined by the likelihood ratio test. Regression analysis results are presented as odds ratios (OR) and 95% confidence intervals (CI). For continuous variables, ORs are interpreted per unit of measurement (i.e., per mL, per year, and per operation). P<0.05 was considered significant. All statistical analyses were performed using JMP Pro, version 19.0 (SAS Institute Inc., Cary, NC, USA).

RESULTS

The study enrolled 340 patients undergoing total thyroidectomy: 182 in the no-loupes group and 158 in the loupes group. The mean age of the entire cohort was 54.3 ± 14.6 years (median 57; range 13-81). Overall, 296 patients (87.1%) were female. Demographic and clinical characteristics, stratified by group, are shown in Table 1. The loupes group was significantly younger (51.6 ± 15.5 vs. 56.6 ± 13.4 years, p=0.001) and had a smaller median thyroid volume (26.2 mL vs. 34.4 mL, p=0.001). Despite smaller volumes, this group had a significantly higher proportion of malignant diagnoses (48.7% vs. 34.6%; χ^2=6.96; p=0.008). The groups did not significantly differ in sex distribution (χ^2=3.24; p=0.072).

The loupes group had significantly fewer complications. The rate of temporary hypocalcemia decreased from 50.0% (91/182) in the no-loupes group to 32.9% (52/158) in the loupes group (χ^2=10.13; p=0.002). The

TABLE 1. Demographic and clinical characteristics of patients and the rate of hypocalcemia

Variable		The use of loupes during surgery		p-value*
		no (N=182)	yes (N=158)	
Age (years), mean ± standard deviation		56.6 ± 13.4	51.6 ± 15.5	0.001
Sex				0.102
	female	164 (90.1)	132 (83.5)	
	male	18 (9.9)	26 (16.5)	
Thyroid volume (mL)†, median (min-max)		34.4 (0.2-329.5)	26.2 (2.6-226.5)	0.001
Malignancy, n (%)				0.011
	benign	119 (65.4)	81 (51.3)	
	malignant (carcinoma)	63 (34.6)	77 (48.7)	
Temporary hypocalcemia, n (%)				0.002
	no	91 (50.0)	106 (67.1)	
	yes	91 (50.0)	52 (32.9)	
Permanent hypocalcemia‡, n (%)				0.004
	no	132 (72.9)	134 (85.4)	
	yes	49 (27.1)	23 (14.6)	

* Age was compared using Welch's t-test; thyroid volume using the Mann-Whitney U test; categorical variables using the χ^2 test.

† Volume values are based on patients with available thyroid size data (N=150 for the without-loupes group, N=126 for the with-loupes group).

‡ Percentages for permanent hypocalcemia are calculated based on the number of followed patients (N=181 for the no-loupes group, N=157 for the loupes group).

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rate of permanent hypocalcemia significantly decreased from 27.1% in the no-loupes group to 14.6% in the loupes group (χ^2=8.36; p=0.004).

Risk factor analysis was performed using univariate logistic regression to assess the crude effect of individual factors on the development of hypocalcemia. In patients with temporary hypocalcemia (Table 2), the use of surgical loupes proved to be a significant protective factor (OR 0.49, 95% CI 0.316-0.762; p=0.002). Among demographic factors, female sex was a significant risk factor (OR 2.41, 95% CI 1.176-4.960; p=0.016).

TABLE 2. Univariate analysis of predictors for the development of temporary hypocalcemia

Predictor	Odds ratio	95% confidence interval	p-value
Surgical loupes (yes)	0.49	0.316-0.762	0.002
Cumulative number of operations*	0.997	0.995-0.998	< 0.001
Sex (female)	2.41	1.176-4.960	0.016
Malignancy (yes)	0.78	0.501-1.216	0.276
Age (years)*	1.00	0.988-1.018	0.714
Thyroid volume (mL)*	1.00	0.999-1.010	0.226

* Continuous variable: OR refers to the change in risk per unit of measurement (per unit change).

In patients with permanent hypocalcemia (Table 3), the use of surgical loupes (OR 0.45, 95% CI 0.259-0.782; p=0.004) was a significant protective factor. Unlike for temporary hypocalcemia, thyroid volume was a significant risk factor (p=0.027), where each additional milliliter of volume slightly increased the risk of developing the condition (OR 1.01, 95% CI 1.001-1.014). Other examined variables did not show a significant effect on the permanent outcome.

TABLE 3. Univariate analysis of predictors for the development of permanent hypocalcemia

Predictor	Odds ratio	95% confidence interval	p-value
Surgical loupes (yes)	0.45	0.259-0.782	0.004
Cumulative number of operations*	0.997	0.995-0.999	< 0.001
Thyroid volume (mL)*	1.01	1.001-1.014	0.027
Sex (female)	1.48	0.630-3.480	0.370
Malignancy (yes)	0.98	0.570-1.660	0.932
Age (years)*	1.01	0.990-1.030	0.263

* Continuous variable: OR refers to the change in risk per unit of measurement (per unit change).

Because of the strong collinearity between loupe use and the cumulative number of operations observed in our cohort (Pearson correlation coefficient r=0.86; variance inflation factor =3.87), a stratified multivariate analysis was performed through two models to assess the independent and combined effect of technology and experience on the development of complications. Model A examined the effect of surgical loupes (without the experience variable), while Model B included both the cumulative number of operations and the use of loupes to demonstrate the effect of their collinearity.

Results for temporary hypocalcemia are shown in Table 4. In Model A (loupes only), the use of loupes was confirmed as a significant protective factor (p=0.033), reducing the risk of hypocalcemia by approximately 43% (OR 0.57, 95% CI 0.342-0.955). Model B (both factors) revealed strong collinearity between surgical loupes and experience – their individual effect was not significant (p>0.05), confirming that the introduction of surgical loupes temporally overlapped with the increase in surgical experience. In all models, female sex remained a stable and strong risk factor (p<0.01).

TABLE 4. Multivariate analysis of predictors for the development of temporary hypocalcemia

Predictor	Model A (loupes only) OR (95% CI)	p-value	Model B (loupes and experience) OR (95% CI)	p-value
Surgical loupes (yes vs. no)	0.57 (0.339-0.962)	0.033	1.22 (0.499-2.997)	0.652
Cumulative number of operations*	-	-	0.996 (0.993-1.000)	0.060
Sex (F vs. M)	3.50 (1.440-8.460)	0.006	3.65 (1.489-8.966)	0.005
Malignancy (yes)	1.13 (0.660-1.940)	0.651	1.07 (0.619-1.862)	0.803
Age (years)*	1.00 (0.978-1.015)	0.678	1.00 (0.980-1.016)	0.675
Volume (mL)*	1.00 (0.998-1.008)	0.243	1.00 (0.998-1.008)	0.262

* Continuous variable: OR refers to the change in risk per unit of measurement (per unit change).

TABLE 5. Multivariate analysis of predictors for the development of permanent hypocalcemia

Predictor	Model A (loupes only) OR (95% CI)	p-value	Model B (loupes and experience) OR (95% CI)	p-value
Surgical loupes (yes vs. no)	0.51 (0.262-0.980)	0.043	1.25 (0.422-3.670)	0.686
Cumulative number of operations*	-	-	0.996 (0.992-1.000)	0.035
Sex (F vs. M)	1.55 (0.650-3.690)	0.323	1.58 (0.645-3.864)	0.316
Malignancy (yes)	0.98 (0.500-1.920)	0.963	0.92 (0.463-1.815)	0.806
Age (years)*	1.00 (0.980-1.025)	0.826	1.00 (0.978-1.025)	0.838
Volume (mL)*	1.01 (0.999-1.012)	0.081	1.00 (0.999-1.012)	0.150

* Continuous variable: OR refers to the change in risk per unit of measurement (per unit change).

For permanent hypocalcemia, a similar pattern was observed (Table 5). Model A showed that loupes significantly reduced the risk of permanent damage (p=0.043). In Model B, the effect was distributed, with experience retaining marginal significance (p=0.035), while the use of loupes lost their independent predictive significance. Other variables were not significant predictors of the permanent outcome.

DISCUSSION

In our retrospective cohort, the introduction of loupe magnification during total thyroidectomy was associated with a significant reduction in both transient and permanent postoperative hypocalcemia. The rate of transient hypocalcemia decreased from 50.0% to 32.9%, and that of permanent hypocalcemia from 27.1% to 14.6%.

The baseline rates in the period when we did not use loupes fell within the upper ranges reported in large systematic reviews. In an observational study by Edafe et al, the rate of hypocalcemia varied widely depending on definitions and biochemical thresholds; importantly, female sex, Graves' disease, the need for parathyroid autotransplantation, and inadvertent parathyroid excision were consistently associated with an increased risk (15). A more recent meta-analysis also confirmed that patient- and disease-level variables explained part but not all of the observed heterogeneity between cohorts (5). In this context, the improvement related to the use of loupes during thyroidectomy compares favorably with published evidence. Pata et al (13) reported that loupe magnification improved the preservation of parathyroid tissue and reduced hypocalcemia-related outcomes after total thyroidectomy. This indicates that enhanced visualization of parathyroid glands and their vascular pedicles can translate into measurable reductions in postoperative calcium disturbance (13). In their cohort, the rate of post-thyroidectomy biochemical hypocalcemia was 20.6% in the loupes group vs. 33.9% in no-loupes group, and the rate of clinical hypocalcemia was 12.7% vs. 33%, respectively. Furthermore, they had two surgical teams and fewer patients (13). All patients in the current study were operated on by a single surgeon, which improves technical consistency, and increases the coupling between time, experience, and technique refinements. It, however, makes it difficult to isolate the independent contribution of loupe magnification – an issue we observed statistically through collinearity. On the other hand, a systematic review concluded that magnification did not reduce key complications, including hypocalcemia, although its strength of evidence was limited by a small dataset and variable endpoints (16). More recent clinical studies continue to evaluate loupe magnification primarily from the perspective of complication reduction. For example, a 2024 meta-analysis examining loupe use in thyroidectomy reported RLN injury reduction and trends toward decreased hypocalcemia in the loupe groups, reflecting renewed interest in these relatively low-cost optical adjuncts (17). In addition, comparative clinical data (including non-Western settings) suggest a lower rate of temporary hypocalcemia when loupes are used to aid in the identification of parathyroid glands and RLN, indicating that the effect may be reproducible across different practice environments (18). For permanent hypocalcemia, the literature generally reports lower rates than those observed in our early period, particularly in high-volume, registry-based, or tightly defined biochemical cohorts. For example, Ritter et al reported that while low postoperative PTH was common, most patients recovered parathyroid function, and only a small minority met the criteria for permanent hypoparathyroidism at a longer follow-up (19). Similarly, recent studies often cite permanent hypocalcemia in the low single digits, emphasizing definition sensitivity and the role of case-mix and surgical volume (20). In our study, the relative reduction in permanent hypocalcemia after loupe adoption is therefore particularly meaningful, even if absolute rates remain higher than those reported by some high-volume datasets – likely reflecting differences in definitions (calcium-based vs. PTH-based), supplementation practices, and the inclusion of complex benign disease (large goiters) and malignancy. The risk-factor profile in our study provides clinically intuitive signals. Female sex remained a stable predictor for transient hypocalcemia across multivariable models. The literature studies repeatedly report female sex as a risk factor for early postoperative hypocalcemia, although the underlying mechanism is likely multifactorial (baseline calcium/vitamin D status, hormonal influences, symptom reporting, or biochemical threshold effects, the incidence of thyroid diseases) (5,15). In contrast, thyroid volume was associated with permanent hypocalcemia in univariate analysis. This is consistent with the notion that large glands may require broader mobilization and greater risk of parathyroid devascularization or inadvertent excision, effects that might be more likely to translate into persistent rather than transient dysfunction. While our multivariable permanent models showed volume trending rather than persisting as an independent signal, the directionality remained clinically coherent and aligned with the broader concept that "extent of dissection" variables (large goiter, central compartment dissection, extrathyroidal extension) are meaningful drivers of lasting parathyroid impairment (5). Interestingly, malignancy itself was not a significant predictor in our cohort. This does not necessarily contradict the literature: malignancy becomes a stronger determinant of hypocalcemia risk when it serves as an indicator for central neck dissection, locally invasive disease, or extensive lymphadenectomy. In studies where these operative details are explicitly documented, dissection extent, not malignancy per se, often carries the predictive weight (21).

The American Thyroid Association's statement on postoperative hypoparathyroidism underscores prevention through meticulous surgical technique, preservation of parathyroid blood supply, thoughtful autotransplantation when viability is compromised, and rational postoperative monitoring and supplementation strategies (7). Within this framework, loupe magnification can be viewed as a pragmatic technique support tool: it does not replace surgical principles but it may increase the fidelity with which those principles are applied, particularly during capsular dissection near inferior thyroid poles and in identifying subtle parathyroid tissue embedded in the thyroid or obscured by inflammation/fibrosis.

Several limitations of this study should be acknowledged. First, the retrospective single-center, single-surgeon design inherently limits generalizability. Second, a baseline imbalance between groups was present: patients operated on with loupes were on average younger and had smaller thyroid volumes than controls. However, age was not a significant predictor of either temporary or permanent hypocalcemia in univariate analysis. Also, both age and thyroid volume were included as covariates in all multivariate models, so residual confounding by these factors is unlikely to fully account for the observed protective effect of loupe magnification. Third, the introduction of loupes coincided temporally with an increase in cumulative surgical experience, resulting in strong collinearity (r=0.86) between the two variables; therefore, their independent contributions could not be fully disentangled.

In conclusion, as simple, low-cost, and widely available adjuncts, surgical loupes may contribute to an improved preservation of parathyroid function, particularly when integrated with increasing surgical experience.

Funding
None

Declaration of authorship
BB conceived and designed the study; SF, TK acquired the data; MF analyzed and interpreted the data; all authors drafted the manuscript; BB critically reviewed the manuscript for important intellectual content; all authors gave approval of the version to be submitted; all authors agree to be accountable for all aspects of the work.

Competing interests
All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organization for the submitted work; no financial relationships with any

organizations that might have an interest in the submitted work in the previous 3 years; no other relationships or activities that could appear to have influenced the submitted work.

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