EMBJ.ORG FOR YOUNG DOCTORS

EuroMediterranean Biomedical Journal
2026, 21 (1)
(Formerly: Capsula Eburnea)

**Original article**

# PEDIATRIC THYROID SURGERY: A 7-YEAR EXPERIENCE FROM A HIGH-VOLUME TERTIARY CENTER

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ARTICLE INFO

*Article history:*
*Received 11 February 2026*
*Accepted 7 April 2026*
*Published 11 May 2026*

Keywords:
thyroid gland; children; surgical outcome; complication; total thyroidectomy.

ABSTRACT

Pediatric thyroid diseases are associated with higher malignancy and complication rates than in adults. Despite the 2015 American Thyroid Association pediatric guidelines, literature on pediatric thyroid surgery remains limited. This retrospective study aims to present a 7-year, single-center experience in pediatric thyroid surgery. It was conducted from January 2018 to January 2025 and included 60 patients undergoing nodulectomy, lobectomy, or total thyroidectomy for symptomatic thyroid disorders or suspicious nodules. The median age was 14 years, with 46 (76.7%) females. The most common complaint was neck swelling observed in 35 individuals (58.3%). Preoperatively, 44 patients (73.3%) had thyroid nodules; 41 (68.3%) had benign disease, while 19 (31.6%) were diagnosed with papillary thyroid carcinoma (PTC). A total thyroidectomy was the most common procedure performed in 26 cases (43.3%). A significant correlation was found between surgery duration and hospitalization (r=0.528, p<0.001). Pediatric thyroid surgery is generally safe, with total thyroidectomy being the most frequently performed procedure. Given the relatively high malignancy rate and surgical complexity, optimal outcomes depend on multidisciplinary care and surgeon expertise in pediatric thyroid pathology.

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## Introduction

Pediatric thyroid diseases requiring surgical intervention are rare and include both benign and malignant conditions.[1] Although thyroid cancer accounts for less than 1% of all pediatric malignancies, its incidence is gradually increasing and is often associated with more advanced disease compared to adults. Several factors may contribute to this trend. Increased awareness among both the public and healthcare professionals regarding the signs and risks of thyroid disease has improved early detection. Additionally, greater exposure to environmental pollutants, chemicals, and endocrine-disrupting substances may adversely affect thyroid function in both children and adults. Nutritional deficiencies, particularly low iodine intake, may further increase the risk of thyroid disorders in younger populations. Moreover, contemporary lifestyle factors, including increased psychological stress, may contribute to hormonal imbalance and thyroid dysfunction.[2] Recent studies report that the risk of malignancy in pediatric thyroid nodules ranges from 9% to 50%, with an average of approximately 26%, which is significantly higher than the malignancy rate in adults (approximately 5%).[3,4] These epidemiological findings underscore the clinical importance of thyroid disease in the pediatric age group and highlight the need for dedicated surgical expertise, standardized perioperative protocols, and robust outcome data to guide management decisions in this vulnerable population. Papillary thyroid carcinoma (PTC) accounts for the vast majority (80-90%) of pediatric thyroid malignancies, followed by follicular thyroid carcinoma (approximately 10%), while medullary thyroid carcinoma represents 3-5% of cases. Poorly differentiated thyroid carcinomas are rare in this population. Due to the distinct biological behavior and higher rates of advanced disease at presentation, a more aggressive therapeutic approach is often adopted in children compared to adults. Established risk factors for thyroid malignancy in children include autoimmune thyroid diseases such as Hashimoto's thyroiditis and Graves' disease, iodine deficiency, and exposure to ionizing radiation.[4-6]

Pediatric thyroidectomy, though uncommon, is performed for conditions such as goiters, Graves' disease, thyroid nodules, malignancy, and certain genetic syndromes, with the surgical approach determined by disease extent and clinical indication.[7] The rate of postoperative complications is generally higher in children than in adults, primarily due to the relative rarity of these procedures and limited pediatric surgical experience. Reported complications include hematoma, hypoparathyroidism, hypocalcemia, vocal cord paralysis, recurrent laryngeal nerve injury, and, less commonly, injury to adjacent vascular, tracheal, or esophageal structures.[8] Despite the availability of pediatric-specific guidelines, including the 2015 American Thyroid Association recommendation, evidence on surgical outcomes remains limited.[9] Therefore, real-world data from

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high-volume centers are essential to address this gap, refine best practices, and evaluate the safety, feasibility, and outcomes of pediatric thyroid surgery within a structured multidisciplinary setting. Accordingly, the current study aims to retrospectively analyze seven years of pediatric thyroid surgery at a tertiary referral center, focusing on the spectrum of diseases, surgical procedures performed, postoperative complications, and factors influencing outcomes. All references have been reviewed, and their eligibility has been verified.[10]

## Materials and Methods

### *Study design*

This hospital-based, retrospective, single-center study included pediatric cases managed between January 2018 and January 2025. The study was conducted at the Smart Health Tower, a high-volume tertiary referral center in Iraq. All data were retrieved from the hospital's electronic medical record system and operative logbooks. The study was conducted in accordance with the principles of the Declaration of Helsinki.

### *Inclusion criteria*

Patients were eligible for inclusion if they were ≤18 years of age at the time of surgery and had undergone nodulectomy, lobectomy, or total thyroidectomy, with or without neck dissection. Surgical intervention was indicated for patients presenting with symptomatic thyroid disorders, solitary thyroid nodules, or nodules with a high suspicion of malignancy based on clinical, radiological, or cytological findings. Only those with a clear medical indication for surgery were considered for inclusion. A consecutive case-series approach was applied. All pediatric patients recorded in the institutional surgical database who met the eligibility criteria during the study period were screened. No randomization or matching was performed; all consecutive eligible cases were included to minimize selection bias.

### *Exclusion criteria*

Patients were excluded if their medical records were incomplete. Additional exclusion criteria were: i) patients >18 years at the time of surgery; ii) patients who underwent thyroid surgery for non-thyroid indications (*e.g.*, parathyroid disease alone); iii) patients lost to follow-up before any postoperative data could be recorded; and iv) patients for whom histopathological results were unavailable.

### *Physical examination*

All patients underwent a comprehensive preoperative physical examination. Particular attention was given to the anterior neck region, where inspection and palpation were used to assess the size, location, consistency, and mobility of thyroid swellings (Figure 1). Cervical lymphadenopathy, compressive symptoms (such as dysphagia or dyspnea), and vocal cord function were also evaluated.

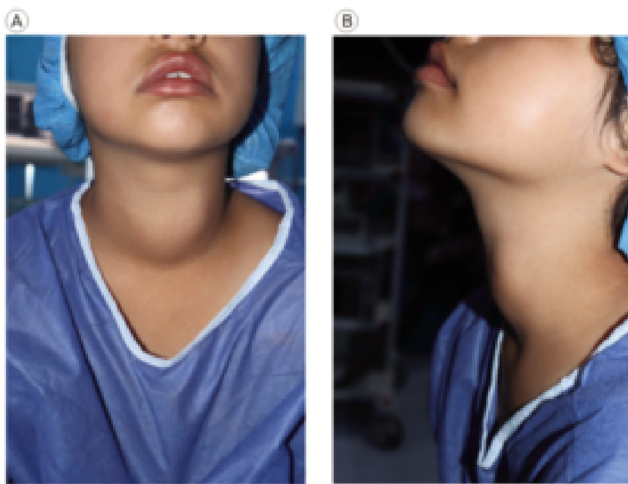


**Figure 1.** Preoperative image of a pediatric patient exhibiting anterior neck swelling: **A**) anterior view; **B**) lateral view.

### *Data collection*

Demographic and clinical data were extracted from electronic medical records. Collected variables included age at surgery, sex, smoking status, relevant medical history, presenting symptoms, physical examination findings, imaging results (ultrasound and/or computed tomography), laboratory investigations (including thyroid function tests), and fine-needle aspiration cytology results. Surgical indication and intraoperative details were also recorded. Postoperative complications were systematically evaluated and classified according to established criteria. Recurrent laryngeal nerve injury was defined as vocal cord dysfunction confirmed by laryngoscopy or persistent postoperative hoarseness. Hypocalcemia or hypoparathyroidism was defined as a serum calcium level <8.5 mg/dL (normal range: 8.5-10.5 mg/dL) or parathyroid hormone (PTH) level <10 pg/mL following thyroidectomy. Complications resolving within 12 months were considered temporary, while those persisting beyond 12 months were classified as permanent, in accordance with American Association of Clinical Endocrinologists guidelines. Other assessed complications included postoperative hematoma, surgical site infection, wound disruption, tracheal injury, and esophageal injury. All patients underwent preoperative vocal cord evaluation by direct visualization. Serum calcium and PTH levels were measured preoperatively, at 24 hours postoperatively, and during follow-up visits in patients undergoing total thyroidectomy or extensive lymph node dissection. Postoperative complications were documented from the immediate postoperative period through the final follow-up visit.

### *Primary and secondary outcome measures*

The primary outcome of this study was the rate of postoperative surgical complications, specifically: i) recurrent laryngeal nerve injury, defined as new-onset vocal cord dysfunction confirmed by direct laryngoscopy or persistent hoarseness beyond the immediate postoperative period; and ii) hypoparathyroidism or hypocalcemia, defined as a serum calcium level below 8.5 mg/dL (reference range: 8.5-10.5 mg/dL) or a PTH level below 10 pg/mL at 24 hours postoperatively or at any follow-up visit. The secondary outcomes included: i) the spectrum and frequency of histopathological diagnoses (benign *vs.* malignant) as determined by postoperative histopathology; ii) the distribution and frequency of surgical procedure types (nodulectomy, lobectomy, total thyroidectomy, and total thyroidectomy with lymph node dissection); iii) the rate of other surgical complications, including postoperative hematoma (defined as any clinically significant wound collection requiring intervention), surgical site infection (defined as wound erythema, purulent discharge, or clinical infection requiring antibiotic treatment or reoperation within 30 days), wound disruption, and intraoperative injury to adjacent structures (trachea or esophagus); iv) operative duration (minutes from skin incision to closure); v) length of hospital stay (days from surgery to discharge); and vi) the correlation between operative duration and length of hospitalization. Thyroid nodules were characterized preoperatively using the American College of Radiology Thyroid Imaging Reporting and Data System (TI-RADS), a validated ultrasound-based classification assigning scores TR1-TR5 based on nodule composition, echogenicity, shape, margin, and echogenic foci. Fine-needle aspiration cytology results were categorized according to the Bethesda System for Reporting Thyroid Cytopathology, a standardized six-tier classification system (Bethesda I-VI) that stratifies malignancy risk and guides clinical management. Goiter severity was graded using the World Health Organization goiter grading system (Grade 0-2), which is based on clinical inspection and palpation.

### *Surgical procedure*

All surgical procedures were performed under general anesthesia. Patients were positioned supine with neck extension supported by a shoulder roll to optimize exposure. A transverse cervical incision was made, followed by elevation of a subplatysmal flap to access the thyroid gland. The extent of resection – nodulectomy, lobectomy, or total thyroidectomy – was determined by the underlying pathology. In cases of Graves' disease or suspected malignancy, careful dissection was performed to ensure complete excision of affected tissue. In selected cases, neck dissection was carried out in accordance with oncologic principles. Hemostasis was ensured, and a closed-suction drain was placed when indicated. The wound was closed in anatomical layers using absorbable and non-absorbable sutures.

### *Postoperative follow-up*

Postoperative care included a scheduled outpatient visit approximately one week after surgery. Patients were subsequently followed for one month to monitor recovery, detect complications, and provide ongoing guidance. Additionally, all patients were provided with a dedicated contact number to report any postoperative concerns, including pain, bleeding, or signs of infection.

### Statistical analysis

All data were entered into Microsoft Excel and subsequently analyzed using the Statistical Package for the Social Sciences (SPSS), version 26.0. The Shapiro-Wilk test was used to assess the normality of continuous variables. For normally distributed data, descriptive statistics were presented as means with standard deviations, while non-normally distributed data were summarized using medians and quartile ranges (QRs). Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate, while continuous variables between groups were compared using the Mann–Whitney U test, given the non-normal distribution of most variables. Correlation between operative duration and length of hospital stay was assessed using Spearman's rank correlation coefficient. A p-value of <0.05 was considered statistically significant for all analyses.

### Sample size and missing data

No formal *a priori* sample size calculation was performed, as this study was a retrospective consecutive case series designed to describe the full institutional experience rather than to test a pre-specified hypothesis with a fixed power. Regarding missing data, patients with incomplete medical records were excluded per the study's exclusion criteria; no imputation was performed. All included patients had at least one postoperative follow-up visit, and no patients were lost to follow-up before postoperative outcomes were documented.

**Table 1.** Demographic, clinical, and laboratory profiles of pediatric patients.

| Patients | n (%) |
|---|---|
| Age (median, QR) | 14 (11-15) |
| Gender | |
| Male | 14 (23.3) |
| Female | 46 (76.7) |
| History | |
| Family history of PTC | 3 (5.0) |
| Down syndrome | 1 (1.7) |
| Thyroid problem | 1 (1.7) |
| None | 55 (91.7) |
| Smoking status | |
| No smoker | 53 (88.3) |
| Passive smoker | 7 (11.7) |
| Main complaint | |
| Anterior neck swelling | 35 (58.3) |
| Weakness | 5 (8.3) |
| Thyroid checkup | 5 (8.3) |
| Incidental | 5 (8.3) |
| Dyspnea | 3 (5.0) |
| Eye protrusion | 3 (5.0) |
| Palpitation | 3 (5.0) |
| Abnormal menstruation | 1 (1.7) |
| Goiter grading | |
| G0 | 6 (10.0) |
| G1 | 30 (50.0) |
| G2 | 24 (40.0) |
| Thyroid status | |
| Euthyroid | 30 (50.0) |
| Hyperthyroidism | 21 (35.0) |
| Hypothyroidism | 9 (15.0) |
| Anti-TPO (median, QR) | 18.12 (10.7-192) |
| TRAB (median, QR) | 6.5 (4.0-32.0) |
| Calcium (median, QR) | 9.5 (9.30-9.81) |
| Thyroglobulin (median, QR) | 13.0 (2.0-62.0) |

QR, quartile range; PTC, papillary thyroid carcinoma; TPO, thyroid peroxidase; TRAB, thyrotropin receptor antibodies.

## Results

Among the 60 patients included in the study, the median age was 14 years (IQR: 11-15), with 46 females (76.7%). A family history of PTC was reported in 3 cases (5.0%). The most common presenting complaint was anterior neck swelling, observed in 35 patients (58.3%). Goiter grading revealed that half of the cohort had grade 1 goiter (30 patients, 50.0%). Thyroid function assessment showed that 30 patients (50.0%) were euthyroid, 21 (35.0%) were hyperthyroid, and 9 (15.0%) were hypothyroid. Regarding medical history, one patient (1.7%) had Down syndrome, one (1.7%) had a pre-existing thyroid problem, and 55 patients (91.7%) had no relevant prior history. In terms of smoking exposure, 53 patients (88.3%) were non-smokers, while 7 (11.7%) had passive smoking exposure. With respect to preoperative laboratory findings in the subset of patients where these were assessed, the median anti-thyroid peroxidase was 18.12 IU/mL (QR: 10.7-192.0), median thyrotropin-receptor antibody level was 6.5 IU/L (QR: 4.0-32.0), median serum calcium was 9.5 mg/dL (QR: 9.30-9.81), and the median thyroglobulin was 13.0 ng/mL (QR: 2.0-62.0) (Table 1).

Preoperatively, 44 patients (73.3%) were diagnosed with thyroid nodules, 13 (21.7%) with Graves' disease, and 3 (5.0%) with hyperthyroidism. Postoperative histopathological evaluation identified benign disease in 41 patients (68.3%), most commonly Graves' disease (12 cases, 20.0%), while PTC was the only malignant diagnosis, present in 19 patients (31.6%) (Table 2).

In the benign group (n=41), 30 patients were older than 12 years (73.2%), with a female-to-male ratio of 2.15:1. In the malignant group (n=19), 14 patients (73.7%) were older than 12 years; however, female predominance was significantly greater (female-to-male ratio 18:1; p=0.026). Thyroid function status differed significantly between groups (p=0.013), with hyperthyroidism more frequent in benign cases (19 patients, 46.3%) and euthyroidism predominating among malignant cases (12 patients, 63.2%) (Table 3). Regarding imaging findings, the most frequent TI-RADS category was TR2 (14 patients, 23.3%), followed by TR3 (13, 21.7%) and TR5 (10, 16.7%). Cervical lymph nodes were reported as inflammatory or suspicious in 8 patients (13.3%) each. Fine-needle aspiration cytology demonstrated a significant difference between benign and malignant groups (p<0.001). Benign lesions were most commonly Bethesda II (13 cases, 31.7%), whereas malignant lesions were predominantly Bethesda V (8 cases, 42.1%) and Bethesda VI (5 cases, 26.3%). Operative duration was significantly longer in malignant cases (median 90 minutes, QR: 60-150) compared with benign cases (median 50 minutes, IQR: 45-60) (p=0.002) (Tables 3 and 4). A moderate positive correlation was observed between opera-

**Table 2.** Preoperative and postoperative diagnoses in patients.

| Diagnosis | n (%) |
|---|---|
| Preoperative diagnosis | |
| Thyroid nodule | 44 (73.3) |
| Graves' disease | 13 (21.7) |
| Hyperthyroidism | 3 (5.0) |
| **Postoperative diagnosis (histopathology)** | |
| Benign (goiter-related conditions) | |
| Hyperplastic colloid nodule | 1 (1.7) |
| Hyperplastic thyroid follicular nodule | 10 (16.7) |
| Hyperplastic adenomatoid nodule | 1 (1.7) |
| Multinodular colloid goiter | 4 (6.6) |
| Nodular colloid goiter | 2 (3.3) |
| Thyroid follicular nodular disease | 2 (3.3) |
| Dyshormonogenetic goiter | 3 (5.0) |
| Benign (other conditions) | |
| Active intrathyroidal thymic tissue | 1 (1.7) |
| Adenomatoid thyroid follicular nodule | 1 (1.7) |
| Follicular adenoma | 2 (3.3) |
| Graves' disease | 12 (20.0) |
| Hashimoto's thyroiditis | 1 (1.7) |
| Hyalinizing trabecular tumor | 1 (1.7) |
| Malignant | |
| PTC | 19 (31.6) |

PTC, papillary thyroid carcinoma.

tive time and length of hospital stay (Spearman's ρ=0.528, p<0.001) (Figure 2).

A significant association was found between the type of surgical procedure and final histopathological diagnosis (p=0.001). Among benign conditions, Graves' disease was the most frequent (12 cases, 20.0%), all managed with total thyroidectomy. Hyperplastic follicular nodules accounted for 10 cases (16.7%) and were treated with nodulectomy (5 cases, 62.5%) or lobectomy (4 cases, 25.0%). PTC accounted for all malignant cases (19, 31.6%) (Table 5).

All patients demonstrated normal preoperative vocal cord function. During a median follow-up of 4 years (range: 1-7 years), no cases of permanent vocal cord paralysis or recurrent laryngeal nerve injury were observed. Among the 26

Table 3. Demographic, clinical, and surgical comparison of benign and malignant postoperative diagnoses.

| Variables | Postoperative benign diagnosis (n=41) n (%) | Postoperative malignant diagnosis (n=19) n (%) | p |
|---|---|---|---|
| Age (years) | | | 0.839 |
| 0-3 | 1 (2.44) | 0 (0.0) | |
| 4-7 | 2 (4.88) | 0 (0.0) | |
| 8-11 | 8 (19.51) | 5 (26.32) | |
| >12 | 30 (73.17) | 14 (73.68) | |
| **Female:Male ratio** | **2.15:1.0** | **18.0:1.0** | **0.026** |
| History | | | |
| Family history of PTC | 2 (4.9) | 1 (5.3) | 0.785 |
| Down syndrome | 1 (2.4) | 0 (0.0) | |
| Thyroid problem | 1 (2.4) | 0 (0.0) | |
| None | 37 (90.2) | 18 (94.7) | |
| Main complaint | | | 0.122 |
| Anterior neck swelling | 26 (63.4) | 9 (47.4) | |
| Weakness | 4 (9.8) | 1 (5.3) | |
| Thyroid checkup | 2 (4.9) | 3 (15.8) | |
| Incidental | 2 (4.9) | 3 (15.8) | |
| Dyspnea | 1 (2.4) | 2 (10.5) | |
| Eye protrusion | 3 (7.3) | 0 (0.0) | |
| Palpitation | 3 (7.3) | 0 (0.0) | |
| Abnormal menstruation | 0 (0.0) | 1 (5.3) | |
| Goiter grading | | | 0.281 |
| G0 | 3 (7.3) | 3 (15.8) | |
| G1 | 19 (46.3) | 11 (57.9) | |
| G2 | 19 (46.3) | 5 (26.3) | |
| Thyroid status | | | 0.013 |
| Euthyroid | 18 (43.9) | 12 (63.2) | |
| Hyperthyroidism | 19 (46.3) | 2 (10.5) | |
| Hypothyroidism | 4 (9.8) | 5 (26.3) | |
| Fine-needle aspiration | | | <0.001 |
| Bethesda I | 2 (4.9) | 1 (5.3) | |
| Bethesda II | 13 (31.7) | 0 (0.0) | |
| Bethesda III | 2 (4.9) | 1 (5.3) | |
| Bethesda IV | 2 (4.9) | 1 (5.3) | |
| Bethesda V | 0 (0.0) | 8 (42.1) | |
| Bethesda VI | 0 (0.0) | 5 (26.3) | |
| Not mentioned | 22 (53.7) | 3 (15.8) | |
| Type of operation | | | 0.002 |
| Total thyroidectomy | 19 (46.3) | 7 (36.8) | |
| Right lobectomy | 9 (22.0) | 2 (10.5) | |
| Left lobectomy | 4 (9.8) | 1 (5.3) | |
| Right nodulectomy | 7 (17.1) | 0 (0.0) | |
| Left nodulectomy | 1 (2.4) | 0 (0.0) | |
| Isthmusectomy | 1 (2.4) | 0 (0.0) | |
| Total thyroidectomy + bilateral CLND | 0 (0.0) | 2 (10.5) | |
| Total thyroidectomy + bilateral CLND & LLND | 0 (0.0) | 2 (10.5) | |
| Total thyroidectomy + bilateral CLND + right LLND | 0 (0.0) | 1 (5.3) | |
| Total thyroidectomy + left CLND | 0 (0.0) | 1 (5.3) | |
| Total thyroidectomy + left CLND & LLND | 0 (0.0) | 1 (5.3) | |
| Total thyroidectomy + right CLND & LLND | 0 (0.0) | 2 (10.5) | |
| Duration of operation (median, QR) | 50.0 (45.0-60.0) | 90.0 (60.0-150.0) | 0.002 |

CLND, central lymph node dissection; LLND, lateral lymph node dissection; QR, quartile range; PTC, papillary thyroid carcinoma.

patients who underwent total thyroidectomy, preoperative serum calcium levels had a mean value of 9.5 mg/dL (reference range: 8.5-10.5 mg/dL). No cases of transient or permanent hypocalcemia or hypoparathyroidism requiring supplementation were documented.

## Discussion

Thyroid nodules and carcinoma are uncommon conditions in children. Clinically palpable thyroid nodules are reported in approximately 0.5% to 2% of the pediatric population, while ultrasound-based studies estimate the prevalence to be around 3%. The occurrence of these nodules tends to rise with age.[3] Thyroid diseases exhibit a strong female predominance. Females are 4 to 6 times more likely to develop autoimmune thyroid disorders and approximately 3 to 4 times more likely to present with thyroid nodules compared to males.[11] Although sex-based differences in the incidence of thyroid carcinoma are not evident in early childhood, a pronounced female predominance emerges in adolescence and young adulthood, with reported female-to-male ratios reaching approximately 5:1.[12] Consistent with these findings, the present study observed that girls underwent thyroid surgery at a rate three times higher than boys.

Thyroid dysfunction in children is often asymptomatic in its early stages, with clinical suspicion typically arising only after noticeable enlargement of the thyroid gland or the detection of a palpable nodule.[7] A study conducted at a Saudi Arabian teaching hospital reported that neck swelling was a presenting symptom in 22.6% of pediatric patients with thyroid disorders, highlighting its significance as a localized manifestation of thyroid dysfunction.[13] In the current study, anterior neck swelling was the most common chief complaint, observed in 58.3% of patients, which aligns with and expands upon existing literature regarding pediatric thyroid disorders. The higher percentage in this study may reflect differences in population demographics or the severity of cases requiring surgical intervention, as studies often note that neck swelling becomes more prominent in advanced or structural thyroid conditions requiring surgical management. The referenced Saudi study reflects a broad outpatient endocrine clinic population encompassing biochemical thyroid disorders, subclinical autoimmune disease, and conditions that frequently present without structural gland enlargement. By contrast, the present cohort is exclusively surgical, and therefore inherently enriched for conditions in which visible or palpable neck swelling is a cardinal feature, namely nodular goiter, Graves' disease requiring thyroidectomy, and malignancy. A Nigerian study similarly documented anterior neck swelling as the dominant presentation in a surgically and clinically referred pediatric thyroid population, where euthyroid goiter – a condition defined by structural gland enlargement in the absence of functional derangement – was among the most prevalent diagnoses.[14] This parallel is instructive: both the Nigerian series and the present cohort are clinic- or surgery-referred populations selected for structural thyroid disease, and both report substantially higher rates of neck swelling than general endocrine outpatient series. The convergence of findings across two geographically and demographically distinct populations strengthens the interpretation that high rates of neck swelling in surgical pediatric thyroid series are a predictable consequence of case-mix selection, not a population-specific anomaly.

Recent studies indicate that pediatric thyroid nodules carry a higher risk of malignancy (19-26.4%) compared to adults (approximately 5%), although the majority remain benign in nature.[15] The most frequently encountered benign thyroid conditions in children include Graves' disease, chronic autoimmune thyroiditis (Hashimoto's thyroiditis), colloid goiter, and thyroid adenomas.[16] First-line management typically involves anti-thyroid medications; however, when medical therapy is ineffective or not tolerated, surgical intervention or radioactive iodine therapy may be considered as alternative treatment options.[17] It is important to note that the use of radioactive iodine in pediatric patients, particularly those under five years of age, has raised concerns due to its potential association with an increased risk of secondary malignancies.[17] In the present study, histopathological evaluation demonstrated that 68.3% of cases were benign, with Graves' disease being the most prevalent diagnosis, accounting for 20.0% of the cohort.

Pediatric thyroid malignancies comprise several histological types with

| | Duration of operation (Minutes) | |
|---|---|---|
| Length of hospital stay | Correlation Coefficient | .528** |
| | Sig. (2-tailed) | [illegible] |
| | N | 60 |
| ** Correlation is significant at the 0.01 level (2-tailed). | | |

Figure 2. Correlation between the duration of surgery and the length of hospitalization.

Table 4. Radiological, cytological, and surgical characteristics of thyroid nodules.

| Variables | n (%) |
|---|---|
| Ultrasound findings of the thyroid nodule (TI-RADS) | |
| TR1 | 6 (10.0) |
| TR2 | 14 (23.3) |
| TR3 | 13 (21.7) |
| TR4 | 5 (8.3) |
| TR5 | 10 (16.7) |
| Thyroiditis | 12 (20.0) |
| US detected cervical lymph nodes | |
| Inflammatory lymph nodes | 8 (13.3) |
| Suspicious lymph nodes | 8 (13.3) |
| None | 44 (73.3) |
| Fine-needle aspiration | |
| Bethesda I | 3 (5.0) |
| Bethesda II | 13 (21.7) |
| Bethesda III | 3 (5.0) |
| Bethesda IV | 3 (5.0) |
| Bethesda V | 8 (13.3) |
| Bethesda VI | 5 (8.3) |
| Not mentioned | 25 (41.7) |
| Type of operation | |
| Total thyroidectomy | 26 (43.3) |
| Right lobectomy | 11 (18.3) |
| Left lobectomy | 5 (8.3) |
| Right nodulectomy | 7 (11.7) |
| Left nodulectomy | 1 (1.7) |
| Isthmusectomy | 1 (1.7) |
| Total thyroidectomy + bilateral CLND | 2 (3.3) |
| Total thyroidectomy + bilateral CLND + LLND | 2 (3.3) |
| Total thyroidectomy + bilateral CLND + right LLND | 1 (1.7) |
| Total thyroidectomy + left CLND | 1 (1.7) |
| Total thyroidectomy + left CLND + LLND | 1 (1.7) |
| Total thyroidectomy + right CLND + LLND | 2 (3.3) |
| Operation duration (minutes) (median, range) | 60.0 (30.0-240.0) |
| Hospitalization time (days) (median, range) | 1.0 (1.0-3.0) |
| Follow-up duration (years) (median, range) | 4.0 (1.0-7.0) |

TI-RADS, Thyroid Imaging Reporting and Data System; US, ultrasound; CLND, central lymph node dissection; LLND, lateral lymph node dissection.

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distinct biological behaviors and varying prevalence. PTC is the most common subtype, accounting for approximately 80-90% of cases in children and adolescents. It frequently presents with bilateral thyroid involvement and has a strong tendency for regional lymph node metastasis, while distant spread to the lungs is less common. Follicular thyroid carcinoma represents the second most frequent subtype, comprising about 5-10% of pediatric cases. It typically presents as a solitary lesion within the thyroid and tends to spread hematogenously to distant sites such as the lungs and bones, with less frequent lymphatic involvement. Medullary thyroid carcinoma is relatively rare, accounting for 3-5% of pediatric thyroid cancers, and originates from parafollicular C cells. It is often associated with inherited syndromes, particularly multiple endocrine neoplasia type 2, especially in younger patients. Poorly differentiated thyroid carcinoma and anaplastic thyroid carcinoma are extremely rare in the pediatric population and are seldom encountered in clinical practice.[6] In a 5-year retrospective study examining thyroid surgery in pediatric patients, PTC was the only histological type detected among all cases of thyroid malignancy. No cases of follicular, medullary, or anaplastic carcinoma were identified.[7] Similarly, a 20-year review of thyroid surgeries involving 39 pediatric patients reported that PTC was the predominant type, detected in 12 (63.2%) of the 19 malignancies identified.[18] Consistent with these findings, the current 7-year experience of pediatric thyroid surgeries also identified PTC as the sole malignant histological type.

Previous studies emphasized that optimal surgical management of pediatric thyroid disease requires a multidisciplinary approach, particularly close collaboration between surgeons and endocrinologists.[3,19] However, the question of which surgical specialty is best suited to perform thyroid surgery in children remains a subject of ongoing debate.[1] Pediatric surgeons often have limited exposure to thyroid procedures, whereas endocrine or general surgeons, despite higher procedural volumes, may have relatively limited experience with pediatric-specific considerations. This imbalance has been highlighted in the literature, with questions raised as to whether surgical outcomes are more strongly influenced by patient age specialization or by procedural experience, particularly given that both pediatric and endocrine surgeons may perform relatively few pediatric thyroidectomies each year.[20] More recent data suggest that this debate may be less dependent on specialty designation and more strongly influenced by operative volume. In a 2021 study, Keane *et al.* examined the distribution of surgical specialties involved in pediatric thyroidectomy. Their analysis of data from 1999 to 2017 demonstrated a notable shift in surgical practice, with the proportion of pediatric thyroidectomies performed by general surgeons decreasing from 60% to 18%, while those performed by pediatric surgeons increased from 18% to 42% over the same period. A key concept introduced in their study is "surgeon volume", defined as the number of thyroidectomies performed annually by an individual surgeon. Their findings showed that higher surgeon volume was significantly associated with improved postoperative outcomes. Surgeons performing more than 30 thyroidectomies per year were classified as high-volume and were associated with markedly lower complication rates.[21] Of all the factors analyzed, surgeon volume emerged as the most influential determinant of patient outcomes in thyroid surgery, reinforcing broader evidence that higher operative volume is associated with reduced morbidity in complex surgical procedures.[22] These findings are consistent with broader surgical literature indicating that procedural volume is a critical factor in reducing morbidity, particularly in technically demanding operations such as thyroidectomy.[21,22] Within this context, the findings of the present study support the growing emphasis on surgical volume over subspecialty. Despite pediatric cases representing only a minority of the overall workload, the institution's high annual thyroid surgery volume (approximately 750 cases) may contribute to the favorable outcomes observed. However, this interpretation should be approached with caution. The absence of complications in this cohort may reflect not only surgical expertise but also factors such as case selection, perioperative protocols, and the limitations inherent to retrospective data collection. Overall, the current results align with existing evidence suggesting that high-volume centers achieve improved outcomes in pediatric thyroid surgery. Rather than resolving the debate between pediatric and endocrine surgeons, these findings reinforce the concept that cumulative surgical experience and institutional expertise may be more relevant determinants of outcome than specialty alone.

In the present study, a total of 60 pediatric patients underwent thyroid surgery over an 84-month period. Although the sample size may appear modest, it is comparable to previously published series. Earlier studies have reported case volumes ranging from 25 to 106 pediatric thyroidectomies, typically collected over longer periods spanning 3 to 20 years. These reports correspond to an average annual surgical rate of approximately 2 to 8 cases. In comparison, the current study demonstrates a slightly higher annual rate of 8.6 cases, despite the shorter study period.[3,20,23,24]

The surgical management of pediatric thyroid disorders encompasses sev-

**Table 5.** Distribution of histopathological diagnoses according to the type of thyroid operation.

| Histopathology | Type of operation, n (%) | | | | | | | | | | p |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Isthmusectomy | Lobectomy | Nodulectomy | Total thyroidectomy | Total thyroidectomy + bilateral CLND | Total thyroidectomy + bilateral CLND & LLND | Total thyroidectomy + bilateral CLND + right LLND | Total thyroidectomy + left CLND | Total thyroidectomy + left CLND & LLND | Total thyroidectomy + right CLND & LLND | |
| Adenomatoid thyroid follicular nodule | 0 (0.0) | 0 (0.0) | 1 (12.5) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0.001 |
| Active intrathyroidal thymic tissue | 0 (0.0) | 1 (6.3) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Dyshormonogenetic goitre | 0 (0.0) | 0 (0.0) | 0 (0.0) | 3 (11.5) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Follicular adenoma | 0 (0.0) | 1 (6.3) | 1 (12.5) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Graves' disease | 0 (0.0) | 0 (0.0) | 0 (0.0) | 12 (46.2) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Hyalinizing trabecular tumor | 0 (0.0) | 1 (6.3) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Hyperplastic adenomatoid nodule | 0 (0.0) | 1 (6.3) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Hyperplastic colloid nodule | 0 (0.0) | 1 (6.3) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Hyperplastic thyroid follicular nodule | 1 (100.0) | 4 (25.0) | 5 (62.5) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Multinodular colloid goiter | 0 (0.0) | 2 (12.5) | 0 (0.0) | 2 (7.7) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Nodular colloid goitre | 0 (0.0) | 2 (12.5) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Hashimoto's thyroiditis | 0 (0.0) | 0 (0.0) | 0 (0.0) | 1 (3.8) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| PTC | 0 (0.0) | 3 (18.8) | 0 (0.0) | 7 (26.9) | 2 (100.0) | 2 (100.0) | 1 (100.0) | 1 (100.0) | 1 (100.0) | 2 (100.0) | |
| Thyroid follicular nodular disease | 0 (0.0) | 0 (0.0) | 1 (12.5) | 1 (3.8) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Total | 1 (100.0) | 16 (100.0) | 8 (100.0) | 26 (100.0) | 2 (100.0) | 2 (100.0) | 1 (100.0) | 1 (100.0) | 1 (100.0) | 2 (100.0) | |

CLND, central lymph node dissection; LLND, lateral lymph node dissection; QR, quartile range; PTC, papillary thyroid carcinoma.

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eral approaches, such as total thyroidectomy, near-total thyroidectomy, subtotal thyroidectomy, and lobectomy, with the choice of procedure guided by the underlying pathology and extent of disease involvement.[7] Although thyroidectomy is a commonly performed operation overall, it remains relatively uncommon in the pediatric population, with only a small proportion of the approximately 50,000 annual procedures performed in children. Indications for surgery include compressive goiters, Graves' disease, thyroid nodules, thyroid malignancies, and prophylactic surgery in familial endocrine syndromes such as multiple endocrine neoplasia.[18] In the present study, total thyroidectomy was the most frequently performed procedure, accounting for 26 cases (43.3%), with 19 patients in the benign group and 7 in the malignant group. This predominance likely reflects the high prevalence of diffuse thyroid diseases within the cohort, particularly in Graves' disease and multinodular goiter, where bilateral involvement is common. In such settings, total thyroidectomy offers definitive treatment, reduces the risk of recurrence, and eliminates the need for reoperation, which is associated with higher complication rates.[9] However, the preference for total thyroidectomy in benign disease may also reflect institutional practice patterns and the influence of a high-volume surgical environment. While this approach aligns with strategies aimed at definitive management, it should be balanced against the potential risk of complications, particularly in pediatric patients. Thyroid surgery in the pediatric population is associated with a distinct profile of postoperative complications. Recent studies consistently identify transient hypoparathyroidism as the most frequent complication, occurring in up to 24% of cases. It typically presents within 24-48 hours postoperatively and is usually self-limiting, resolving within weeks, though permanent hypoparathyroidism may occur, especially following total thyroidectomy combined with central neck lymph node dissection. Recurrent laryngeal nerve injury resulting in vocal cord paralysis is uncommon but clinically significant, as the smaller caliber and increased fragility of the nerve in younger children can make intraoperative identification and preservation more challenging. Accordingly, intraoperative nerve monitoring has been recommended as an adjunct to reduce this risk. Other complications, including postoperative hemorrhage, hematoma, wound infection, and keloid formation, are reported infrequently. Existing literature further emphasizes that complication rates are multifactorial and influenced by the extent of surgery, surgeon experience, and institutional case volume, with high-volume centers consistently demonstrating lower morbidity. Compared with adults, pediatric patients appear to have a higher risk of transient hypocalcemia, although permanent complications remain uncommon unless more extensive procedures, such as lymph node dissection for malignancy, are performed.[20,25,26] In this study, at a median follow-up period of four years, no complications were observed. While this finding is encouraging, it should be interpreted cautiously in light of existing literature reporting measurable complication rates in similar populations. The absence of complications may reflect the effects of high institutional surgical volume and expertise; however, the possibility of under-detection in a retrospective design and the relatively small sample size must also be considered.

This study is subject to several limitations that must be considered. First, the retrospective design may introduce inherent methodological constraints, including limited control over data completeness and variable standardization. Second, the relatively small sample size may limit the statistical power of the study and reduce the ability to detect less common outcomes or subtle associations. However, it is important to note that the cohort represents all consecutive eligible cases managed at a high-volume tertiary center over seven years, and no formal sample size calculation was applicable given the descriptive, registry-based nature of the study. The sample size is consistent with those reported in comparable published series. Third, variations in surgical expertise and individual surgeon experience may have influenced outcomes, despite being performed within a specialized center. Additionally, procedural details, such as the extent of thyroid resection, intraoperative decision-making, and perioperative care, may vary and were not uniformly standardized across all cases. Finally, the single-center design of the study may limit external validity, as institutional practices and patient populations may differ from those at other centers. Future multicenter, prospective studies with larger sample sizes are warranted to validate these findings and enhance external validity.

## Conclusions

This study indicates that pediatric thyroid surgery can be performed without major complications, while the observed malignancy rate underscores the clinical importance of careful evaluation and management. Given the relatively high malignancy rate and surgical complexity, optimal outcomes depend on multidisciplinary care and surgeon expertise in pediatric thyroid pathology.

**Conflict of interest:** the authors have no conflict of interest to declare.

**Ethical approval and patient consent for publication:** ethical approval was waived by the Institutional Review Board due to the retrospective nature of the study. Written informed consent was obtained from the patients' guardians for the publication of the present study and any accompanying images.

**Availability of data and materials:** the datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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