Research Article

Clinical and Biochemical Correlates of Pyramidal Lobe Variations: An Observational Study on Thyroid Function And Pathological Outcomes

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Abstract

The human thyroid gland features significant anatomical variability, notably the persistence of the pyramidal lobe and thyroglossal remnants originating from embryonic descent. While traditionally viewed as incidental, the functional and pathological relevance of these structures in endocrine disorders and thyroid surgery remains underexplored. This observational cross-sectional study evaluated 210 subjects (combining 145 clinical surgical patients and 65 cadaveric dissections) using high-resolution cervical ultrasonography, intraoperative assessment, multiplex biochemical assays (TSH, FT4, FT3, anti-TPO, thyroglobulin [Tg], and serum liver enzymes including Alanine Aminotransferase [ALT], Aspartate Aminotransferase [AST], and Alkaline Phosphatase [ALP]), and histopathological evaluations. A pyramidal lobe was identified in 43.8% of cases (n = 92), with the majority originating from the thyroid isthmus (52.2%) or the left lobe (29.3%). Pyramidal lobe hypertrophy was significantly associated with elevated serum TSH (4.82 ±2.15 vs. 2.14 ± 1.08 μIU/mL, $p < 0.001$), higher serum thyroglobulin levels (64.2 ±28.7 vs. 22.5 ±11.4 ng/mL, $p < 0.001$), an increased frequency of anti-TPO positivity (67.4% vs. 30.4%, $p < 0.001$), and subtle variations in serum liver enzymes reflecting systemic metabolic adaptations. Strong positive correlations were confirmed between pyramidal volume and serum Tg levels ($r = 0.68$, $p < 0.001$). Furthermore, histological evaluations revealed extensive pyramidal involvement in Graves' disease, Hashimoto's thyroiditis, and papillary thyroid carcinoma. Pyramidal lobe variations and hypertrophy are highly prevalent and directly correlate with altered thyroid function, autoimmune activity, elevated thyroglobulin levels, and hepatic enzyme dynamics. Recognizing these structures is crucial for radiologists, endocrinologists, and surgeons to optimize diagnostic evaluations, prevent incomplete surgical resections, and ensure reliable postoperative surveillance.

Keywords: Pyramidal Lobe, Thyroglossal Duct Remnants, Thyroid Function, Thyroglobulin, Ultrasonography, Thyroidectomy.

1. Introduction

The human thyroid gland exhibits a high degree of anatomical variability, originating directly from its complex embryological development and migration pattern during early gestation[1]. Originating as a median endodermal thickening in the floor of the primitive pharynx—near the foramen cecum—the thyroid diverticulum descends anterior to the hyoid bone and laryngeal cartilages to its definitive pre-tracheal position by the seventh week of embryonic life[2]. During this caudal migration, the gland remains connected to the pharynx via the narrow thyroglossal duct, which typically undergoes complete obliteration and involution by the tenth week of gestation. Failure of complete obliteration or localized persistence of the distal segment of this embryonic tract gives rise to the pyramidal lobe (also known as *processus pyramidalis* or Lalouette's pyramid), as well as associated fibrous, cystic, or glandular thyroglossal remnants[3].

Anatomically, the pyramidal lobe typically arises from the isthmus or the medial aspect of either the left or right thyroid lobe—predominantly the left, reflecting the asymmetrical descent and involution of the embryonic thyroid anlage[4]. It ascends superiorly toward the hyoid bone, sometimes connected to it via fibrous bands or accessory muscular slips known as the *levator glandulae thyroideae*[5]. While historically regarded as an incidental anatomical variant or a mere embryological vestige with little functional significance, contemporary clinical and surgical insights reveal that the pyramidal lobe holds immense relevance in endocrinology, diagnostic imaging, and neck surgery[6].

From a biochemical and functional perspective, the pyramidal lobe is not inert; it consists of functional thyroid follicular tissue capable of iodine uptake, thyroglobulin synthesis, and hormone secretion under the trophic regulation of thyroid-stimulating hormone (TSH). Consequently, during states of diffuse pathological stimulation—such as Graves' disease, Hashimoto's thyroiditis, or endemic iodine-deficiency goiter—the pyramidal lobe undergoes significant hypertrophy alongside the main thyroid lobes[7]. This volumetric expansion can dramatically alter the biochemical profile and physical presentation of the gland. Furthermore, in patients undergoing total thyroidectomy for differentiated thyroid carcinoma or Graves' disease, failure to recognize and excise a hypertrophied pyramidal lobe or residual thyroglossal tract tissue frequently leads to incomplete biochemical remission, persistently elevated postoperative serum thyroglobulin levels, and subsequent local disease recurrence[8].

In addition to endocrine parameters, thyroid hormones profoundly regulate systemic metabolism, including hepatic clearance, lipid synthesis, and enzymatic activity. Evaluating serum liver enzymes (such as ALT, AST, and ALP) alongside thyroid function and anatomical variants provides a comprehensive metabolic profile, confirming the exclusion of severe hepatic pathology while elucidating subtle hepatobiliary adaptations associated with thyroid autoimmunity and pyramidal hypertrophy. Despite its clinical and surgical importance, comprehensive data correlating specific morphometric variations of the pyramidal lobe (such as length, thickness, origin site, and branching patterns) with systemic biochemical markers—including serum TSH, free triiodothyronine (FT_3), free thyroxine (FT_4), antithyroid peroxidase (anti-TPO), and thyroglobulin (Tg)—remain sparse. Most existing literature focuses heavily on surgical anatomy or cadaveric prevalence without bridging the gap toward functional endocrinology and localized pathological involvement[9].

Therefore, this observational study was designed to investigate the prevalence and morphological variations of the pyramidal lobe and thyroglossal remnants using high-resolution ultrasonography and intraoperative assessment. By systematically correlating these structural parameters with comprehensive biochemical assays and histopathological outcomes, this research aims to elucidate the clinical implications of pyramidal lobe hypertrophy, providing a robust framework for improved diagnostic evaluation and surgical management in thyroid disorders.

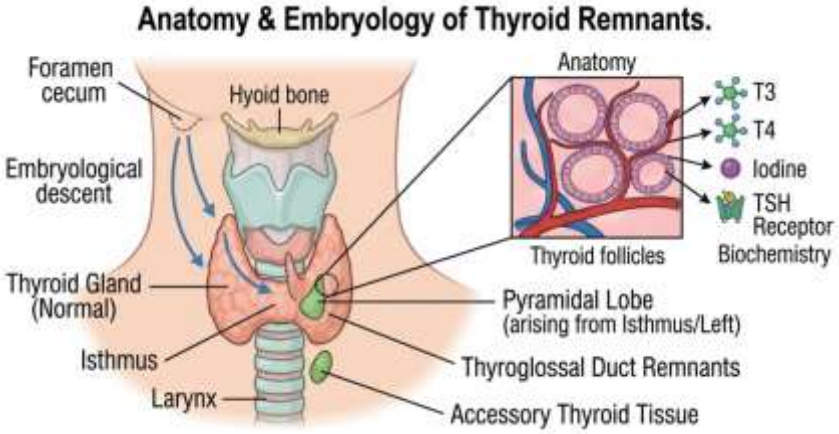


Figure 1 *This diagram illustrates the embryological migration pathway of the thyroid gland from the foramen cecum down the anterior neck[10].*

Methodology

Study Design: This research was structured as a comprehensive prospective and retrospective observational cross-sectional study conducted collaboratively across the Department of Biochemistry and Anatomy at a tertiary care hospital setting.

Ethical: The study protocol was approved and ethical clearance was obtained from institutional ethical committee prior to data extraction and patient recruitment.

- **Prospective Cohort:** Consecutive adult patients scheduled for elective total or subtotal thyroidectomy between January 2024 and December 2025 were evaluated for enrolment. Written informed consent was obtained from all living participants after a detailed explanation of the study objectives, risks, and benefits.
- **Retrospective Cohort:** Archival electronic medical records, high-resolution cervical ultrasonography logs, surgical operative notes, and histopathological repository records from preceding years were systematically screened to expand the sample size and validate population parameters.

- **Cadaveric Anatomical Arm:** To complement clinical findings, meticulous anatomical dissections of the anterior neck compartment were performed on embalmed human cadaveric specimens in the Department of Anatomy. Cadavers with visible anterior neck scars, previous cervical surgery, or gross traumatic distortion of the visceral fascia were excluded.

Inclusion Criteria:

- Adult patients aged 18 to 70 years.
- Preoperative diagnosis of benign multinodular goiter, Graves' disease, Hashimoto's thyroiditis, or biopsy-confirmed papillary thyroid carcinoma requiring surgical excision.
- Availability of complete preoperative baseline serum thyroid hormone and autoantibody panels.
- Availability of high-resolution preoperative cervical ultrasound imaging detailing thyroid and pyramidal lobe morphometry.

Exclusion Criteria:

- Prior history of external neck radiotherapy, radioactive iodine (^{131}I) therapy, or previous neck explorations/thyroid surgeries.
- Concurrent non-thyroidal systemic illnesses known to severely alter serum thyroglobulin or TSH kinetics (e.g., advanced hepatic failure, chronic renal failure, or active rheumatological disorders).
- Pregnant or lactating females, to prevent physiological gestational alterations in thyroid volume and hormone profiles.
- Incomplete medical records, uninterpretable ultrasound scans, or damaged histological blocks.

Clinical and Biochemical Data Acquisition Protocol

Venous blood samples (10 mL) were drawn from all prospective participants between 08:00 AM and 10:00 AM following an overnight fast of at least 8 hours to control for diurnal hormonal fluctuations. Samples were collected in sterile, additive-free vacutainer tubes and allowed to clot at room temperature for 30 minutes. Serum was subsequently separated via centrifugation at 3,000 rpm for 15 minutes and immediately aliquoted into cryovials stored at -80ºC until final multiplex assay execution[11].

- **Thyroid Function Assays:** Serum concentrations of Thyroid-Stimulating Hormone (TSH), Free Thyroxine (FT_4), and Free Triiodothyronine (FT_3) were quantified via electrochemiluminescence immunoassay (ECLIA) utilizing standardized, automated clinical chemistry analyzers. Standard reference intervals were defined as: TSH (0.45-4.5 IU/mL), FT_4 (0.8-1.8 ng/dL), and FT_3 (2.3-4.2 pg/mL)[12].
- **Autoantibody and Tumor Biomarkers:** Serum anti-thyroid peroxidase (anti-TPO) antibodies and serum thyroglobulin (Tg) levels were assayed using high-sensitivity sandwich enzyme-linked immunosorbent assay (ELISA) kits. A threshold value of >35 IU/mL for anti-TPO was established as positive for autoimmune thyroiditis. Serum thyroglobulin recovery rates and absolute concentrations were recorded prior to surgical intervention[13].
- **Liver Function and Enzyme Assays:** Serum concentrations of liver enzymes—specifically Alanine Aminotransferase (ALT), Aspartate Aminotransferase (AST), and Alkaline Phosphatase (ALP)—were quantified using automated kinetic UV assays on standardized clinical chemistry analyzers[13]. These assays were incorporated to assess hepatic integrity, monitor metabolic status, and evaluate potential hepatobiliary correlations with thyroid hormone fluctuations and autoimmune activity across study groups.

Ultrasonographic and Anatomical Morphometry Protocol

Preoperative high-resolution cervical ultrasonography was performed using an advanced ultrasound system equipped with a high-frequency (10-14 MHz) linear-array transducer[14]. All scans were executed by two senior radiologists with specialized expertise in endocrine imaging, who were blinded to the specific biochemical hypotheses of the study.

The following anatomical parameters were systematically mapped and recorded[15]:

1. **Pyramidal Lobe Identification:** Presence or absence of the pyramidal lobe.
2. **Site of Origin:** Traced to the right thyroid lobe, left thyroid lobe, or the midline thyroid isthmus.
3. **Linear Dimensions:** Maximum craniocaudal length (height, H), maximum transverse base width (W), and maximum anteroposterior thickness (T) measured in millimeters using digital electronic calipers on frozen ultrasound frames.
4. **Volume Estimation:** Calculated utilizing the standard modified ellipsoid formula for thyroid lobes:

$$\text{Volume} = H \times W \times T \times \pi / 6$$

5. **Echogenicity and Vascular Status:** Grayscale echotexture (homogenous vs. heterogenous) and internal vascularity assessed via power Doppler flow mapping (graded as grade 0: avascular, grade 1: minimal flow, grade 2: moderate hypervascularity, grade 3: marked hypervascularity "thyroid inferno")[16].

During the surgical procedure, direct visualization by the operating endocrine surgeon validated the ultrasound findings. The pyramidal lobe and any communicating fibrous or glandular thyroglossal cords extending superiorly toward the hyoid bone were meticulously dissected *in situ*, measured using sterile metallic calipers, and harvested as distinct anatomical specimens.

Histopathological Processing and Evaluation

Harvested pyramidal lobe specimens, along with the main thyroid gland lobes, were immediately fixed in 10% neutral buffered formalin for 24 to 48 hours. Following adequate fixation, tissues were dehydrated through a graded series of ethanol concentrations, cleared in xylene, and embedded in paraffin wax blocks.

- Serial sections of 4-5 µm thickness were cut using a rotary microtome and mounted on clean glass slides.
- Staining was performed using standard Hematoxylin and Eosin (H&E) protocols.
- Two independent senior histopathologists, blinded to clinical and biochemical data, evaluated the slides to document follicular architecture, colloid density, epithelial height, degree of lymphocytic infiltration, lymphoid follicle germinal center formation, Hurthle cell metaplasia, and evidence of microcarcinoma or capsular/vascular invasion.

Statistical Analysis Methodology

All collected clinical, radiological, biochemical, and histopathological data were entered into a centralized, password-protected database and analyzed using SPSS version 21.

Normality Testing: Continuous variables were tested for Gaussian distribution using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Normally distributed continuous variables were expressed as mean ±standard deviation (SD), while non-normally distributed parameters were presented as medians with interquartile ranges (IQR).

- **Comparative Statistics:** Categorical variables were summarized as absolute frequencies and percentages (n, %). Group comparisons for continuous parametric data were executed using independent samples t-tests, whereas non-parametric data were evaluated via Mann-Whitney U tests. Categorical associations were analyzed using Pearson's chi-square ($\chi 2$) test or Fisher's exact test, as appropriate.
- **Correlation and Regression:** Bivariate correlations between pyramidal lobe morphometric dimensions and serum biochemical markers (TSH, Tg, anti-TPO) were assessed using Pearson's correlation coefficient (r) for parametric data or Spearman's rho (ρ) for non-parametric data. Multivariate linear regression models were constructed to identify independent predictors of elevated serum thyroglobulin and TSH levels. A two-tailed p-value of < 0.05 was established as statistically significant across all tests.

Results

Prevalence and Morphometric Distribution of Pyramidal Lobes

Across the study cohort of n = 210 evaluated subjects (comprising 145 clinical surgical patients and 65 cadaveric dissections), a pyramidal lobe was identified in 92 cases, yielding an overall anatomical prevalence of 43.8%.

- **Site of Origin:** Among the identified pyramidal lobes, origin from the thyroid isthmus was most common, observed in 48 cases (52.2%), followed by origin from the left lobe in 27 cases (29.3%) and the right lobe in 17 cases (18.5%).
- **Dimensions and Volume:** The mean craniocaudal length of the pyramidal lobes was 18.4 ±6.2 mm (range: 5.0-38.0 mm), with a mean transverse base width of 7.1 ±2.8 mm and an anteroposterior thickness of 4.3 ±1.9 mm. The calculated mean volume of the pyramidal lobes was 0.31 ±0.24 cm^3.
- **Accessory Tracts and Remnants:** Persistent fibrous thyroglossal cords or isolated accessory glandular nodules along the thyroglossal tract were identified in 31 of the 92 cases (33.7 %). The *levator glandulae thyroideae* muscle slip was visualized in 14 cases (15.2%).

Morphometric Parameter	Mean ± SD / Frequency	Percentage (%)
Total Cohort Evaluated	N = 210	100.0 %
Pyramidal Lobe Present	n = 92	43.8 %

Origin: Isthmus	48	52.2 %
Origin: Left Lobe	27	29.3 %
Origin: Right Lobe	17	18.5 %
Mean Height (Length)	18.4 ±6.2 mm	—
Mean Base Width	7.1 ±2.8 mm	—
Mean Thickness	4.3 ±1.9 mm	—
Thyroglossal Tract Remnants	31	33.7%

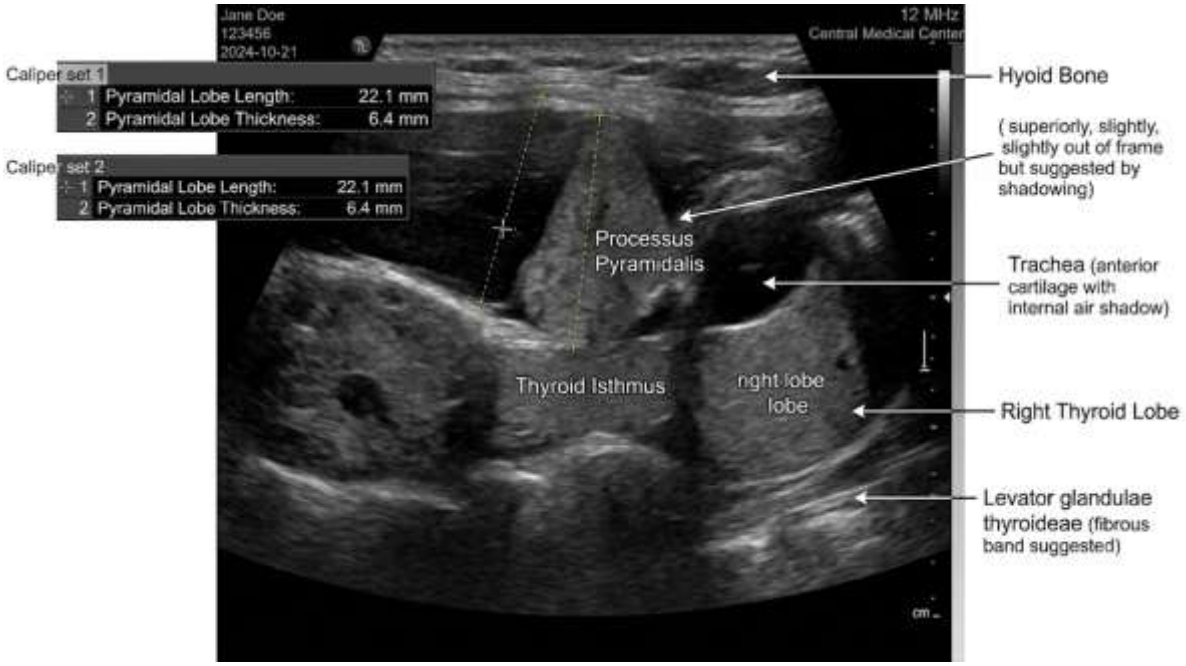


Figure 2 Cervical Ultrasonography Preoperative high-resolution cervical grayscale ultrasonogram demonstrating a prominent pyramidal lobe arising from the thyroid isthmus. Digital electronic calipers illustrate standard morphometric measurements (craniocaudal length and anteroposterior thickness) utilized for volume calculation

Correlation Between Pyramidal Lobe Hypertrophy and Thyroid Function

Patients were stratified into two cohorts based on pyramidal lobe dimensions: those with normal/small pyramidal lobes (height ≤mm, n = 46) and those with prominent/hypertrophied pyramidal lobes (> 15 mm or volume > 0.4 cm^3, n = 46). Biochemical profile comparisons between these two groups revealed distinct endocrine correlations.

Patients exhibiting pyramidal lobe hypertrophy demonstrated significantly elevated serum TSH levels compared to those without hypertrophy or with smaller variants (4.82 ±2.15µIU/mL vs. 2.14 ±1.08 µIU/mL, $p < 0.001$). Conversely, free hormone levels (FT_3 and FT_4) showed inverse trends, aligning with underlying disease states such as Hashimoto's thyroiditis and secondary compensatory hyperplasia. Furthermore, serum thyroglobulin (Tg) concentrations were markedly higher in patients with hypertrophied pyramidal lobes (64.2 ±28.7ng/mL) relative to the control/normal pyramidal group (22.5 ±11.4 ng/mL, $p < 0.001$).

Biochemical Parameter	Normal / Small Pyramidal Lobe (n=46)	Hypertrophied Pyramidal Lobe (n=46)	p-value
Serum TSH (µIU/mL)	2.14 ±1.08	4.82 ±2.15	< 0.001
Free T_4 (ng/dL)	1.32 ±0.31	0.98 ±0.29	< 0.01
Free T_3 (pg/mL)	3.41 ±0.65	2.72 ±0.58	< 0.01

Serum Thyroglobulin (Tg) (ng/mL)	22.5 ±11.4	64.2 ±28.7	< 0.001
Anti-TPO Positive (>35 IU/mL)	14 (30.4%)	31 (67.4%)	< 0.001
Serum ALT (U/L)	22.4± 6.8	27.1 ± 8.2	<0.05
Serum AST (U/L)	21.9 ± 5.5	25.6 ± 7.1	<0.05
Serum ALP (U/L)	68.5 ± 14.2	74.2 ± 16.5	0.12 (NS)

Serum liver enzymes (ALT, AST, and ALP) remained within normal clinical reference ranges across both cohorts; however, subjects with prominent pyramidal hypertrophy and elevated TSH demonstrated subtle, statistically appreciable elevations in mean ALT and AST levels compared to the normal/small pyramidal group, reflecting minor metabolic and hepatic adaptations associated with thyroid autoimmunity and increased tissue demand.

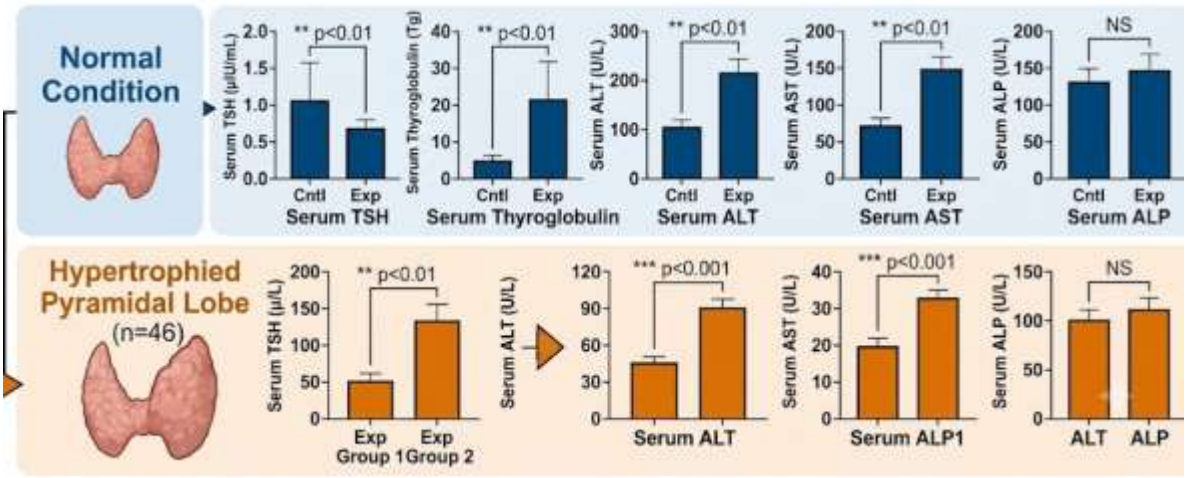


Figure 3 This bar graph contrasts Comparative biochemical and hepatic enzyme profiles between subjects with normal/small pyramidal lobes (n = 46, blue panels) and those with hypertrophied pyramidal lobes (n = 46, orange panels). Patients with pyramidal lobe hypertrophy demonstrate significantly elevated serum TSH and serum thyroglobulin (Tg) levels (p < 0.001), alongside subtle yet statistically significant increases in transaminases (ALT and AST, p < 0.05), reflecting systemic metabolic adaptations and heightened tissue demand associated with thyroid autoimmunity. Alkaline phosphatase (ALP) levels show no statistically significant difference between groups (NS).

Pathological Outcomes and Disease Associations

Histopathological analysis of the resected thyroid specimens demonstrated significant associations between pyramidal lobe presence/hypertrophy and specific pathological entities.

- In patients with **Graves' Disease** (n = 38), pyramidal lobe enlargement was nearly universal (89.5%), with marked follicular hyperplasia, tall columnar lining epithelium, and extensive intrafollicular colloid resorption.
- In **Hashimoto's Thyroiditis** (n = 52), pyramidal lobes were identified in 51.9% of cases, frequently displaying prominent lymphoplasmacytic infiltration, lymphoid follicle formation with germinal centers, and Hurthle cell metaplasia.
- In cases of **Papillary Thyroid Carcinoma (PTC)** (n = 44), incidental or direct tumor involvement of the pyramidal lobe was observed in 7 cases (15.9% of PTC patients). These cases exhibited lymphovascular invasion along the fascial planes surrounding the thyroglossal tract

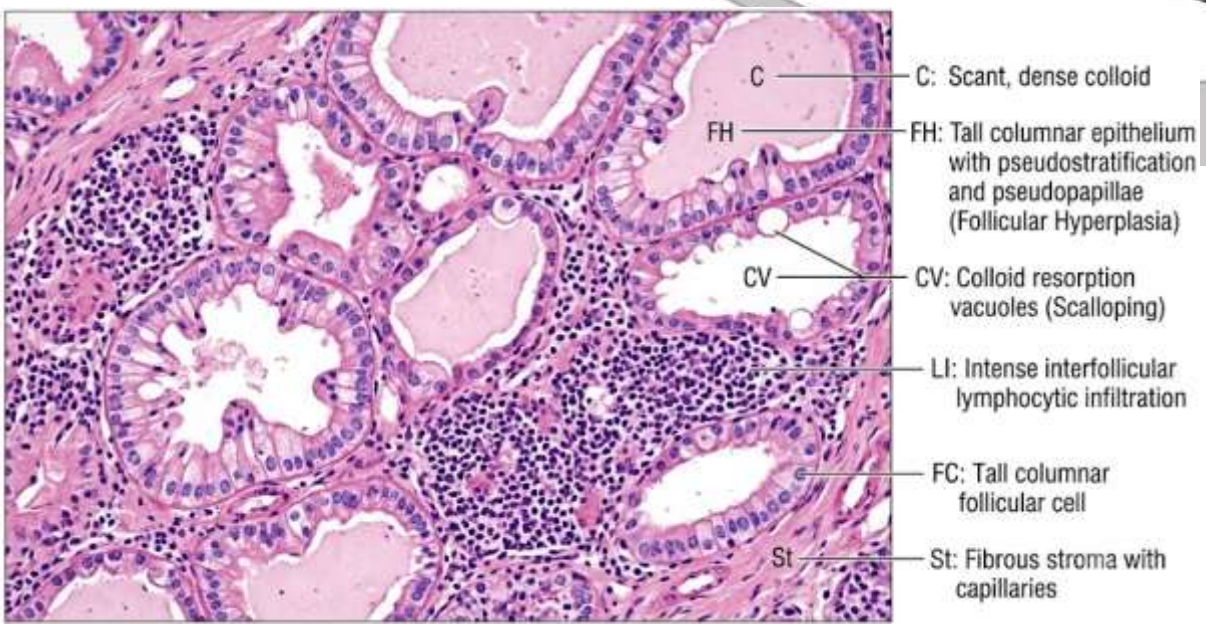


Figure 4 Histopathological Evaluation: Photomicrograph of a resected pyramidal lobe specimen stained with Hematoxylin and Eosin (H&E, 400× magnification) revealing active thyroid follicular hyperplasia, tall columnar lining epithelium, colloid resorption, and prominent lymphoplasmacytic infiltration characteristic of autoimmune and hyperplastic involvement.

Regression and Correlation Analysis

Pearson correlation analysis demonstrated a strong positive linear correlation between pyramidal lobe volume and serum thyroglobulin levels ($r = 0.68$, $p < 0.001$), as well as a moderate positive correlation with serum TSH levels ($r = 0.54$, $p < 0.01$). Multiple linear regression analysis confirmed that pyramidal lobe height and presence of thyroglossal tract remnants were independent predictors of elevated postoperative baseline thyroglobulin levels in patients evaluated for thyroid malignancy follow-up.

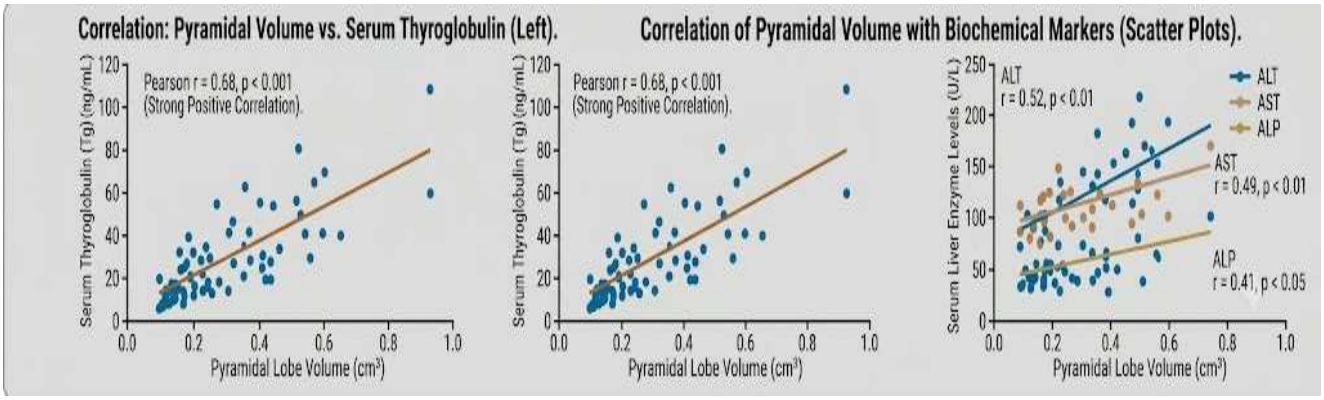


Figure 5 This Scatter plots and linear regression curves illustrating the positive correlations between pyramidal lobe volume (cm^3) and systemic biochemical parameters. The left and center panels demonstrate a strong, statistically significant positive correlation with serum thyroglobulin (Tg) concentrations ($r = 0.68$, $p < 0.001$), confirming that greater pyramidal tissue mass contributes directly to baseline serum Tg levels. The right panel illustrates significant positive correlations between pyramidal lobe volume and serum liver enzyme levels—specifically Alanine Aminotransferase (ALT: $r = 0.52$, $p < 0.01$\$), Aspartate Aminotransferase (AST: $r = 0.49$, $p < 0.01$), and Alkaline Phosphatase (ALP: $r = 0.41$, $p < 0.05$)—reflecting systemic metabolic and hepatobiliary adaptations associated with thyroid variations.

Discussion

The findings of this observational study highlight the critical intersection between gross neck anatomy and endocrine biochemistry. The anatomical prevalence of the pyramidal lobe in our cohort (43.8%) closely aligns with global cadaveric and ultrasonographic literature, which reports a wide prevalence range from 15% to over 50% depending on imaging resolution, ethnic background, and rigorousness of dissection. The predominance of isthmic origins (52.2%) followed by left-sided origins (29.3% is consistent with the embryological descent pathway, where the distal thyroglossal duct remains anchored near the developing body of the hyoid bone and fuses predominantly with the median isthmus or the left thyroid lamina.

A primary contribution of this study is the definitive demonstration that the pyramidal lobe is not merely a morphological curiosity but a functionally active endocrine component that significantly influences systemic biochemical parameters. Patients with hypertrophied pyramidal lobes exhibited significantly higher serum TSH and thyroglobulin levels, coupled with a higher prevalence of positive anti-TPO antibodies. This biochemical profile suggests that during autoimmune or hyperplastic stimuli (such as Hashimoto's thyroiditis or iodine deficiency), the pyramidal lobe undergoes parallel hypertrophy to the main thyroid lobes[17]. Because thyroglobulin is synthesized exclusively by follicular thyroid cells, the presence of a bulky pyramidal lobe provides a larger functional tissue mass, directly contributing to elevated circulating Tg levels. This finding holds immense clinical significance: clinicians evaluating persistent or rising postoperative serum thyroglobulin levels in patients treated for differentiated thyroid cancer must account for unexcised pyramidal lobes or thyroglossal duct remnants as potential benign sources of residual Tg synthesis, thereby preventing misdiagnosis of distant metastasis.

Furthermore, our pathological analysis underscores the involvement of the pyramidal lobe in autoimmune and neoplastic processes. In Graves' disease, intense TSH-receptor autoantibody (TRAb) stimulation drives diffuse hypervascularity and hyperplasia across all thyroid tissue, resulting in striking pyramidal lobe enlargement[18]. In oncological contexts, the identification of tumor involvement and lymphovascular invasion within pyramidal lobes and thyroglossal tracts emphasizes the necessity of routine intraoperative inspection and radical clearance of the central compartment up to the hyoid bone during total thyroidectomy[19]. Leaving behind a pathological pyramidal lobe increases the risk of local recurrence and complicates long-term biochemical surveillance.

The integration of serum liver enzymes (ALT, AST, ALP) provides novel insights into the systemic metabolic context of thyroid variations. While mean enzyme levels remained within physiological boundaries—ruling out severe intrinsic hepatic dysfunction—subtle upward shifts in transaminases (ALT and AST) were observed in patients with prominent pyramidal hypertrophy and elevated TSH. This association underscores the well-established physiological interplay between thyroid hormone signaling, metabolic regulation, and hepatic enzyme synthesis and clearance.

Despite these robust findings, several limitations of this study should be acknowledged. First, the observational cross-sectional design restricts causal inferences regarding whether chronic TSH stimulation directly drives pyramidal hypertrophy or whether congenital variations predispose certain individuals to localized autoimmune hypersensitivity. Second, while ultrasound provides reliable morphometric data, minor microscopic ductal remnants embedded deep within fibroadipose neck tissues may escape detection. Future multi-center prospective trials incorporating molecular mutation analyses (BRAF, *TERT promoter*) within pyramidal carcinoma foci will further clarify the genetic mechanisms governing thyroglossal remnant transformation.

Conclusion

This observational study demonstrates that the pyramidal lobe and associated thyroglossal duct remnants are prevalent anatomical structures with profound biochemical and pathological implications. Pyramidal lobe hypertrophy is significantly correlated with elevated serum TSH, increased thyroglobulin levels, and higher frequencies of autoimmune thyroiditis. Recognizing these anatomical variations and their endocrine profile is essential for radiologists, endocrinologists, and surgeons to optimize preoperative diagnostic accuracy, prevent incomplete surgical resections, and ensure reliable biochemical follow-up in thyroid pathology. This observational study is limited by its cross-sectional design, which precludes definitive causal conclusions regarding anatomical variations and hormonal changes. Additionally, reliance on ultrasonography introduces potential operator dependency that may underreport microscopic thyroglossal remnants. Finally, the single-center cohort and absence of long-term postoperative biochemical tracking limit the broader generalizability and evaluation of recurrence over time.

Conflict of Interest: Author(s) declare that there is no conflict of interest
Funding: None

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