

A Cross-sectional Morphometric Study of Thyroid Glands in Cadavers

SHRISH PATIL, D ANUPAMA, MADHUMATI V NIDONI, SIDRAMAPPA GOUDA

ABSTRACT

Introduction: Thyroid gland is an organ with a highly variable morphology. Despite several studies having been done to assess its measurements, a consensus has not been arrived at as to what constitutes a 'normal' thyroid.

Aim: To determine the dimensions of the normal thyroid gland obtained from cadavers of South Indian region and to derive the mean and standard deviations of the measurements of the gland in the given population, thus contributing to the existing data. We also aimed to study three common but not constant components of the thyroid gland, namely Pyramidal Lobe (PL), Tubercle of Zuckerkandl (TZ) and Levator Glandulae Thyroideae (LGT).

Materials and Methods: The study was conducted on thyroid glands obtained from cadavers of South Indian region. Institutional ethics committee approval was obtained. Sixty thyroid glands were obtained from cadavers received for either routine dissection or autopsies. The thyroid glands were studied after adequate exposure and

fixing in formalin. Dimensions were measured using Vernier calipers. Specimens with anomalies like absent isthmus etc were excluded from the study. Statistical analysis was done using the MedCalc Version 17.0 software.

Results: The average dimensions of the lobes were: height 3.83 cm, width 2.62 cm, and thickness 2.69 cm. The average dimensions of the isthmus were: height 1.38 cm, width 1.36 cm and thickness 1.29 cm. The average dimensions of the pyramidal lobe were: height 2.03 cm, width at the base 1.91 cm and thickness 1.16 cm. Pyramidal lobe was present in 60% of cases. Levator glandulae thyroideae was observable in three cases (5%). Significant correlation was found between the dimensions of right and left lobes and regression equations were calculated.

Conclusion: The dimensions of the thyroid gland are very variable. Knowledge of the wide ranging variations and measurements will be of help to surgeons and radiologists in correct interpretation, diagnosis and treatment of thyroid diseases.

Keywords: Levator glandulae thyroideae, Morphology, Organ size, Pyramidal lobe

INTRODUCTION

Thyroid gland is an endocrine gland located on the front of the neck. Evolutionarily, it is similar to the endostyle of the tunicates and amphioxus [1], which was meant for concentration and storage of scarce iodine in the fresh water environments [2]. Morphological variations and anomalies of the thyroid gland are very common. Marshall, in the year 1895, goes to the extent of calling absurd the term 'normal' thyroid gland [3]. More importantly, these variations may not affect the health of an individual nor cause any symptoms per se and hence go undiscovered and unreported. Thyroid gland surgeries are performed routinely for the several disorders afflicting it. A thorough knowledge of the anatomy of the thyroid gland and its variations is essential for surgeons and to reduce the incidence of wrong interpretation of radiographic and ultrasonographic investigations. Dimensions of the gland may be correlated with anthropometric measurements and are

dependent on the race and sex of the individuals.

The purpose of this study was to conduct measurements of the thyroid glands in cadavers with emphasis on the Pyramidal Lobe (PL), Tubercle of Zuckerkandl (TZ) and Levator Glandulae Thyroideae (LGT) in the population under study. This study contributes to the existing morphometric data and will help in better understanding of the thyroid gland.

MATERIALS AND METHODS

In this cross-sectional study, thyroid glands were obtained from the embalmed cadavers received for routine dissection and also from those received for autopsy at Basaveshwara Medical College and Hospital, Chitradurga, Karnataka, India, and Sri Siddhartha Institute of Medical Sciences, Tumkur, Karnataka, India. The study was conducted over three years from December 2011 to December 2014 after obtaining Institutional Ethical Committee approval. The glands obtained

from the bodies received for medico-legal autopsy were fixed immediately in 10% formalin solution. A total of 60 thyroid glands were included in the study. All adult cadavers with no external injuries on the neck, received during the period of study were included.

Thyroid glands were exposed by a midline incision and by lateral displacement of overlying structures. A block of tissue including the tongue, larynx, trachea and thyroid glands along with related blood vessels and nerves was obtained. The greatest dimension of the glands was used for taking all readings. Measurements of the PL, when present were taken at the widest dimension. The part to which the PL attached was noted. Measurements of the LGT were taken at the least dimensions and attachments were noted. Measurements were taken using electronic slide calipers (Mitutoyo, Japan, Least count- 0.01).

The specimens with ectopic tissue, accessory thyroid, thyroglossal duct remnants and anomalies were excluded from the study.

RESULTS

Of the 60 specimens 27(45%) were from male cadavers and 33(55%) were from female cadavers. The mean age of the males was 44.03 ± 12.76 years and that of females was 42.78 ± 12.86 years.

The average dimensions of the lobes were: height 3.83 cm, width 2.62 cm and thickness 2.69 cm. The dimensions of lobes of the thyroid with standard deviations and the range are shown in [Table/Fig-1].

The average dimensions of the isthmus were: height 1.38 cm,

width 1.36 cm and thickness 1.29. The isthmus was irregularly shaped in most of the cases. The dimensions of isthmus of the thyroid with standard deviations and the range are shown in [Table/Fig-2].

PL was found in 36 cases (60%). The incidence of PL was equal in both sexes-18 out of 36 i.e., 50%. The average dimensions of the pyramidal lobe were: height 2.03 cm, width at the base 1.91 cm, thickness 1.16 cm [Table/Fig-3]. Seven PLs were on the right side, 14 on the left and 15 were attached to the isthmus.

TZ was present in 40 of 60 specimens (66.66%). Of the 40 specimens 16 were bilateral, 11 were present only on right side and 13 only on left side. The distribution is shown in [Table/Fig-4]. The dimensions of TZ were not measured.

LGT was found in only 03 of the 60 cases (5%). The average measurements of the LGT were: length- 3.63 cm, width-0.35 cm and thickness-0.28 cm.

There was no significant difference between right and left lobe dimensions as indicated by paired 't'-test. Paired 't'-test results were as follows:

Between right and left lobe heights- $t(59) = 1.584$, $p > 0.05$;
Between right and left lobe widths- $t(59) = 0.128$, $p > 0.05$;
Between right and left lobe thickness- $t(59) = 0.949$, $p > 0.05$

Correlation statistics were obtained between age and dimensions of the gland. There was a negative correlation between age and height of the lobes of the gland which was not statistically significant ($r = -0.073$) (95% CI = -0.32 to 0.18). Correlation between lobe width and age was also negative and was not statistically significant ($r = -0.13$) (95% CI = -0.38

	Mean Height (in cm)	Range (Max – Min)	Mean Width (in cm)	Range (Max – Min)	Mean Thickness (in cm)	Range (Max – Min)
Male	3.96 (0.38)	3.21 – 4.75	2.63 (0.31)	2.13 – 3.38	2.49 (0.40)	1.23 – 3.27
Female	3.71 (0.33)	3.00 – 4.40	2.60 (0.28)	2.03 – 3.41	2.85 (0.38)	2.09 – 3.78
Combined	3.83 (0.38)	3.00 – 4.75	2.62 (0.30)	2.03 – 3.41	2.69 (0.43)	1.23 -3.78

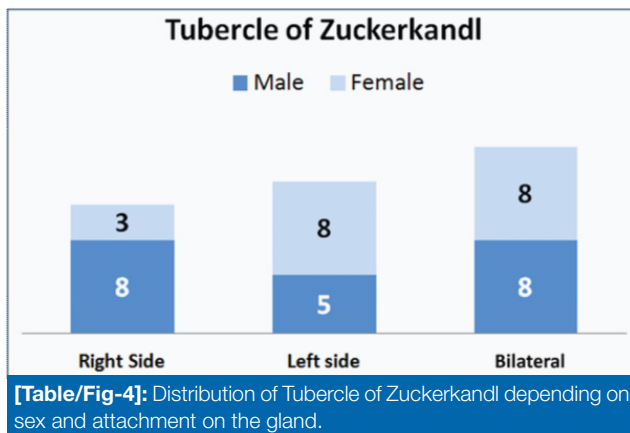
[Table/Fig-1]: Dimensions of Lobe of the thyroid gland (SD in parentheses).

	Mean Height (in cm)	Range (Max – Min)	Mean Width (in cm)	Range (Max – Min)	Mean Thickness (in cm)	Range (Max – Min)
Male	1.36 (0.11)	1.19 -1.62	1.35 (0.10)	1.21 – 1.7	1.26 (0.14)	1.06 – 1.62
Female	1.40 (0.10)	1.21 – 1.67	1.37 (0.10)	1.22 – 1.69	1.31 (0.21)	1.12 – 2.14
Combined	1.38 (0.11)	1.19 – 1.67	1.36 (0.10)	1.21 – 1.70	1.29 (0.18)	1.06 – 2.14

[Table/Fig-2]: Dimensions of Isthmus of thyroid gland (SD in parentheses).

	Mean Height (in cm)	Range (Max – Min)	Mean Width (in cm)	Range (Max – Min)	Mean Thickness (in cm)	Range (Max – Min)
Male	2.09 (0.78)	1.01- 3.39	2.04 (0.71)	1.12 – 3.21	1.14 (0.25)	0.21 – 1.35
Female	1.96 (0.63)	1.07 – 3.21	1.79(0.58)	1.13 -3.06	1.17 (0.10)	1.01 – 1.44
Combined	2.03 (0.70)	1.01 -3.39	1.91 (0.65)	1.12 -3.21	1.16 (0.19)	0.21 – 1.44

[Table/Fig-3]: Dimensions of the pyramidal lobe (SD in parentheses).



to 0.13). There was a positive correlation between age and lobe thickness ($r = 0.11$) (95% CI = -0.1407 to 0.3606), which was not statistically significant.

Regression analysis has shown that significant association between the heights of right and left lobes ($p < 0.0001$). Regression equation can be denoted as:

$$y = 0.9367 + 0.7403 x.$$

Similarly, significant association was found between the widths of right and left lobes ($p = 0.0007$), regression equation can be denoted as $y = 1.6223 + 0.3818 x$; Significant association was also obtained between the thicknesses of right and left lobes ($p < 0.0001$), regression equation can be denoted as:

$$y = 1.1006 + 0.6047 x.$$

STATISTICAL ANALYSIS

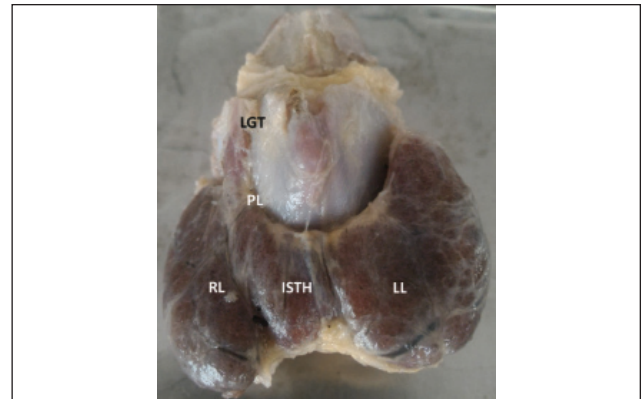
Statistical analyses were performed using MedCalc for Windows, version 17.0 (MedCalc Software, Ostend, Belgium).

DISCUSSION

Embryology: The thyroid gland develops from the floor of the oral cavity and is first identifiable at three to four weeks of gestation. It is the first endocrine gland to develop. At fifth week of intrauterine life the upper part of the thyroglossal duct degenerates and the lower end forms two lobes connected by an isthmus which start functioning by twelfth week. Adult levels of circulating thyroid hormones are reached by 35 weeks of age. In some, the lower end of the thyroglossal duct fails to obliterate and persists as the (PL) [4].

Evolution: Iodine was an essential element for early organisms. It has been proposed that thyroid hormones were evolved to trap iodine from the environment when life moved from iodine-rich marine environment to the iodine-scarce fresh water [2]. It has been said that production of these hormones within the body was an important first step for a better regulation of the metabolic processes in the body. In the non-vertebrate chordates (cephalochordates) this role was taken up by the organ named endostyle which is homologous to the vertebrate thyroid gland.

Gross Anatomy: The thyroid gland (Greek; Thyreos = Shield, eidos = form) is a butterfly shaped organ located on the front of the neck under the sternothyroid, sternohyoid and omohyoid



[Table/Fig-5]: Thyroid gland showing RL- Right lobe, LL- Left lobe, Isth- Isthmus, PL- Pyramidal lobe, LGT- Levator glandulae thyroideae.

muscles, at the level of C5 to T1 vertebrae. It weighs about 12 to 20 g. It has two lobes connected by a thin and narrow isthmus [Table/Fig-5].

The lobes are conical in shape and measure about 5 cm in height, 1.5 to 2.0 cm anteroposteriorly and 2.0 to 3.0 cm transversely. The bases of the lobes are at the level of fourth or fifth tracheal rings. The apices are at the level of the oblique line on the laminae of the thyroid cartilage. The isthmus measures 1.25 to 1.5 cm both vertically and horizontally. The measurements obtained by us in the present study are in agreement with those reported earlier. The isthmus usually lies at the level of second to fourth tracheal rings [5,6].

The thyroid gland is well known for variations, so much so that there can be no definition of a 'normal' thyroid gland. Several of the variations are in the thyroglossal duct- in the form of cysts. Ectopic thyroid tissue may be found elsewhere in the body. Accessory thyroid glandular tissue may be found along the thyroglossal duct and such a tissue may cause diagnostic difficulties.

Pyramidal Lobe (Synonyms - Lobe of Lalouette, Morgagni's Appendix): The PL of the thyroid is a very commonly found embryological remnant stated to be present in about 50% of the population [7]. During thyroidectomies removal of the PL is important lest recurrence occurs. The PL is said to be always involved pathologically in diffuse thyroid diseases like Hashimoto's disease. The exact prevalence of PL is not known. In published literature it has been stated to be ranging from 12% to 80% [8]. Using loupe magnification a PL was found in 82 % of patients undergoing thyroidectomies, by Prabhakaran et al. Of these, majority (70%) were on the left side [9]. In another study by Zivic et al., the PL was found in 61% of cases undergoing thyroid surgeries. In this study the PL was found more in the midline (49%) than on either the right (36%) or left (15%) sides [8]. In another large study

of the thyroid gland in 166 patients who underwent total thyroidectomy, PL was found to be present in 65.7% (109 out of 166). In this series too the researchers found the PL more in the midline- from the isthmus than on the sides [10]. In the present study the incidence of PL was equal in both sexes (50%). A PL was found in 60% of cases in the present study and most of them were attached to the isthmus of thyroid glands (41.66%). The PL has been reported as being longer in females by several researchers [10-12]. Some researchers have found it to be shorter in females [13]. Findings of some of the researchers are shown in [Table/Fig-6].

In the present study we found that the mean height of PL was more in males, but this was not statistically significant.

Author	Average Length	Average Length in Males	Average Length in Females
Zivic R et al., [8] (2011)	20.13 mm	16.25 mm	20.4 mm
Prabhakaran IY et al., [9] (2015)	29.97 mm in <50 years	Shorter in males	-
	42.3 mm in >50 years	-	
Gurleyik E et al., [10] (2015)	22.7 mm	-	Longer in females
Braun EM et al., [11] (2007)	21.5mm*	14 mm	29mm
Milozovic B et al., [12] (2013)	22.6 mm	-	2.3 mm longer than the mean
Patrizi G et al., [13] (2014)	21 mm*	2.3 cm	1.9 cm

[Table/Fig-6]: Observations of some authors regarding pyramidal lobe.

* Calculated from the data given by the authors.

Tubercle of Zuckerkandl: Madelung is credited with its first description in 1879 [14]. It was also described in 1902 by Zuckerkandl and has been variously described as a posterior, a lateral or a posterolateral projection from the thyroid lobes [15]. The indistinct borders of the lobes are slightly enlarged at the point where the medial and lateral embryological elements meet. TZ was found more commonly (88.4%) in the middle third of the lateral border of thyroid lobe as compared to upper (3.8%) or lower thirds (7.7%) [16]. There is no uniformity in the incidence of TZ among studies conducted in different races and populations as reviewed by Rajapaksha et al., [17]. Size of TZ is as variable as that of the lobes and isthmus. We did not undertake measuring the TZ. Bilobed TZ were found in 4.7% of total thyroidectomies conducted by Mehanna et al., [18]. The authors however concluded that there is no embryological basis for a bilobed TZ and that it must be due to nodular changes in it. The surgical importance of this structure in identifying the Recurrent Laryngeal Nerve (RLN) was described by Pelizzo [19]. This becomes especially true when there is an enlargement of the thyroid gland thus distorting its

shape. In such a scenario the RLN can be identified using TZ as a landmark [20]. Rajapaksha et al., assessed the average distance between TZ and RLN to be 1.2 mm [17]. Knowledge about the location and size of PL when present is important not only for correct identification of the RLN but also for performing an adequate and full resection [21]. The superior parathyroid glands can also be located using the TZ as a landmark [22]. They lie cranial to the TZ. Some researchers have made an attempt to classify/grade the TZ based on its size [19,21]. For a more detailed discussion of the TZ refer Gil-CarcedoSanudo et al., [14].

Levator Glandulae Thyroideae (Synonyms- Soemmering's muscle, Hyo-thyro-glandulaire of Pointe): It is a fibrous or fibromuscular band of tissue connects the thyroid gland to the hyoid bone known as LGT. The LGT has been studied by several researchers, but a consensus on its character, nomenclature, morphological origin etc., is yet to emerge. The origin of this band is unclear [12]. Some authors call it LGT only if it is muscular [5,23]. Harjeet et al., in a large study on 570 thyroid glands authors found the incidence of LGT in 111 specimens (19.5%). The average measurements of LGT in this study were, length 11.5–49.0 mm; breadth 3.0–11.0 mm and thickness 1.0–3.0 mm [24]. The origin of the LGT has been described as being from cricothyroid, thyrohyoid, inferior constrictor of the pharynx, omohyoid etc., [25]. The incidence of LGT also has been stated variably from 0.5% to 85.7% [26]. In the present study we encountered the LGT only in 03 out of 60 specimens (5%) and it was associated with a in all instances [Table/Fig-5].

LIMITATION

The limitation of the present study is that the samples are from a Southern state of India and hence cannot be taken as representative of whole population. A large multicentric study is proposed for better results.

CONCLUSION

The thyroid gland is an organ with great variations in its shape, size and features. The PL is a very common occurrence with no sex predilection and is highly variable in its size, position and dimensions. Significant correlation was found between the dimensions of right and left lobes and regression equations were calculated. TZ is a common occurrence but not ubiquitous. The LGT is an uncommon band of tissue, variably composed of muscle and connective tissues. It connects either the apex of the PL or in its absence the isthmus of thyroid gland to the body of hyoid bone. Knowledge of the variety of variations of the thyroid gland will help in diagnosis, correct interpretation of radiological investigations and also in safe surgical interventions wherever required.

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