Cite as: Akudu LS, Ukoha UU, Ekezie J, Ukoha CC: Ultrasonographic study of the incidence of pyramidal lobe and agenesis of the thyroid isthmus in Nnewi population. J Ultrason; 2018; 18: 290–295.

Submitted: 16.05.2018
Accepted: 14.10.2018
Published: 31.12.2018

Ultrasonographic study of the incidence of pyramidal lobe and agenesis of the thyroid isthmus in Nnewi population

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DOI: 10.15557/JoU.2018.0042

Keywords
thyroid gland, pyramidal lobe, agenesis, Nnewi

Abstract

Introduction: Ultrasound is the most reliable imaging modality for thyroid evaluation due to the limitations in the clinical examination of this gland. Thyroid gland developmental anomalies are rare. Most of its variations are due to the persistence of the thyroglossal duct and the absence of the isthmus. The aim of this study was to determine the incidence of pyramidal lobe and agenesis of the thyroid isthmus in Nnewi population using ultrasound. **Materials and method:** A total of 321 subjects resident in Nnewi, including 167 males and 154 females, were randomized. A written consent was obtained from all patients. The subjects were aged between 18 and 35 years. This was a prospective cross-sectional study. Thyroid glands were scanned using a 2-dimensional ultrasound machine with a 7.5 MHz transducer; model Siemens Sonoline Prima which was made in Japan for Siemens Medical System Incorporated, ultrasound Group, Issaquah, WA, 98029-7002, USA. **Results:** The study revealed no incidence of pyramidal lobe and agenesis of the thyroid isthmus in the study population. **Conclusion:** This study has clearly demonstrated no incidence of pyramidal lobe and agenesis of the thyroid isthmus in subjects resident in Nnewi, Nigeria.

Introduction

The thyroid gland is one of the most commonly imaged glands using ultrasound due to the limitations of clinical examination[(1)]. According to the practice guideline issued by the American Institute of Ultrasound in Medicine (AIUM) in 2007, there are a number of indications for thyroid ultrasound, such as evaluation of the presence, size and location of the thyroid gland, localization and characterization of palpable neck masses, evaluation of abnormalities detected by other imaging modalities or laboratory tests, evaluation for patients with increased risk of thyroid malignancies and follow-up of thyroid nodules[(2)].

The thyroid gland is the largest endocrine gland in humans, weighing about 20 g in an adult[(3)]. The thyroid gland is a notably labile gland that varies greatly in size[(4)]. It is a very important endocrine gland associated with the rate of metabolism, blood calcium levels, as well as the growth and development in mammals[(5)]. The gland varies from an "H" shape[(6,7)] or a "butterfly" shape[(8)] to a "U" shaped[(6,7)] structure. In the presence of the pyramidal lobe, it bears a "butterfly" shape, whereas in the absence of the pyramidal lobe,

it retains the "U" shaped structure. The thyroid gland is situated in the lower front of the neck and consists of two symmetrical lobes. These lobes are united by an isthmus that lies in front of the second, third and fourth tracheal rings[9]. The isthmus is encountered during routine tracheotomy and must be retracted (superiorly or inferiorly) or divided. However, the isthmus is occasionally absent, with the thyroid gland existing as two independent lobes[7]. Additionally, a third lobe called pyramidal lobe of the thyroid gland is occasionally found in 28%–55% of population (mean 44.3%). It has a conical shape and extends from the upper part of the isthmus generally to the left of the midline, up across the thyroid cartilage to the hyoid bone[9,10].

The pyramidal lobe is a remnant of the fetal thyroid stalk, or thyroglossal duct[11]. It is occasionally quite detached, or may be divided into two or more parts. The pyramidal lobe is also known as Lalouette's Pyramid[11]. It may be attached to the inferior border of the hyoid bone by fibrous tissue; it may sometimes contain some muscle fibers known as Levator Glandulae Thyroideae. Separate masses of thyroid tissue (accessory thyroid glands) are not commonly found near the hyoid bone, in the tongue, in the superior mediastinum, or anywhere along the path of descending thyroglossal duct, though their presence may only be revealed by histological studies[9].

The pyramidal lobe is considered a thyroid anomaly[12], morphological variation of the thyroid gland[13] or a normal component of the thyroid gland[14,15]. The pyramidal lobe may be a source of recurrent disease if it is not removed during total thyroidectomy[14–16]. Identification and removal of the pyramidal lobes are of great importance for successful postoperative radioactive iodine treatment in patients with differentiated thyroid carcinoma[17,18]. If the pyramidal lobe is not removed in patients who receive radioactive iodine postoperatively, it will reduce the therapeutic benefit of treatment by absorbing most of the radioactive agent [19].

Varying information about thyroid anomalies may be found in literature. In anatomical studies, the frequency of the pyramidal lobe is between 15% and 75%. In their study on the importance of pyramidal lobe in thyroid surgery, Geraci *et al*. identified pyramidal lobe in only 50% of cases during preoperative diagnostic procedures using either ultrasonography or Tc-99m pertechnetatescintigraphy[18]. In line with their findings, Keith reported that pyramidal lobe is observed in approximately 50% of the population[20]. In another study by Dong *et al.*, the prevalence rates for thyroid pyramidal lobes observed using sonography and at surgery were 56.8% (75 of 132) and 59.8% (79 of 132), respectively[21]. They attributed this high prevalence to a selection bias or the use of different diagnostic tools. Again, Mortensen *et al.*, in their study on the incidence and morphological features of pyramidal lobe on thyroid ultrasound revealed the overall incidence of pyramidal lobe to be 21% among the study subjects[22]. A study on surgical anatomy of the pyramidal lobe and its significance in thyroid surgery reported that the pyramidal lobe was found in 61% of the cases[15]. On the other hand, the incidence of the agenesis of the thyroid isthmus has been reported by various authors[23–25]. Pastor *et al*. claimed that agenesis of the thyroid isthmus is the complete and congenital absence of the thyroid isthmus and is rare in humans[24]. According to the authors, the incidence of absence of the thyroid isthmus varies from 5% to 10%[24]. In their study on anatomical variations of the thyroid gland, Ranade and colleagues reported a 33% incidence of agenesis of the isthmus. Also, a cadaveric study reported the incidence of the isthmus agenesis of the thyroid gland in Bangladesh as 82.2%[25].

Due to its rare nature, isthmus agenesis should be kept in mind for safe surgery to avoid complications during neck operations[26]. Clinically, the diagnosis of agenesis of the isthmus can be made with scintigraphy. It can also be diagnosed with the aid of ultrasonography, computed tomography, magnetic resonance imaging or during a surgical procedure. When isthmus agenesis is observed, a differential diagnosis against autonomous thyroid nodule, thyroiditis, primary carcinoma, neoplastic metastasis and infiltrative diseases like amyloidosis should be considered[27].

It is also important for radiologists to be aware of these normal variations (presence of pyramidal lobe and agenesis of the isthmus), as it may be the site of primary or recurrent thyroid pathology. Radiologists should report it where relevant to ensure adequate surgical treatment of pathological glands[22]. However, Deepa and Shrikrishna (2015) reported that developmental anomalies of the thyroid gland are quiet commonly seen. Most of the variations are due to the partial persistence of the median or thyroglossal duct[28]. Pyramidal lobe and agenesis of the isthmus may be entirely an incidental finding, they can be affected by the same range of pathologies as the remainder of the thyroid, and hence it is important to identify this normal variant[22]. Therefore, knowledge of variations of the thyroid gland is substantial for surgeons dealing with head and neck surgery. Furthermore, the understanding of the thyroid anatomy and its associated anatomical variations is necessary so as not to overlook these anomalies in differential diagnosis[29]. Additionally, studies regarding the incidental and morphological features of the thyroid gland have been conducted in other populations, with only few in local populations using ultrasound. That is to say that local data on the morphology and variations of thyroid glands using ultrasound are scarce. Therefore, this study aimed to determine the occurrence of pyramidal lobe and agenesis of the thyroid isthmus in Nnewi population using ultrasound.

Materials and methods

This was a prospective cross-sectional study conducted in the Department of Radiography, Faculty of Health Science and Technology, College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus, Anambra State. A total of 321 patients (164 females and 157 males) from the investigated region were selected through random sampling technique. The patients were aged between 18 and 35 years. This age range results from the convenience in encouraging these patients, who were mainly students, to participate in the study.

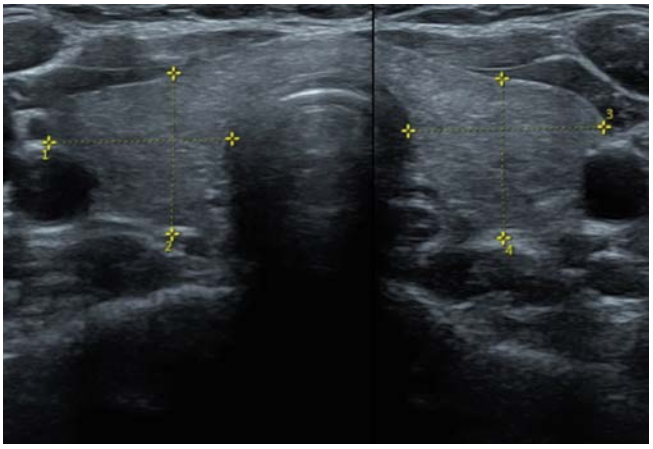

Fig. 1. *Sonogram presenting the width and the thickness of the thyroid lobes*

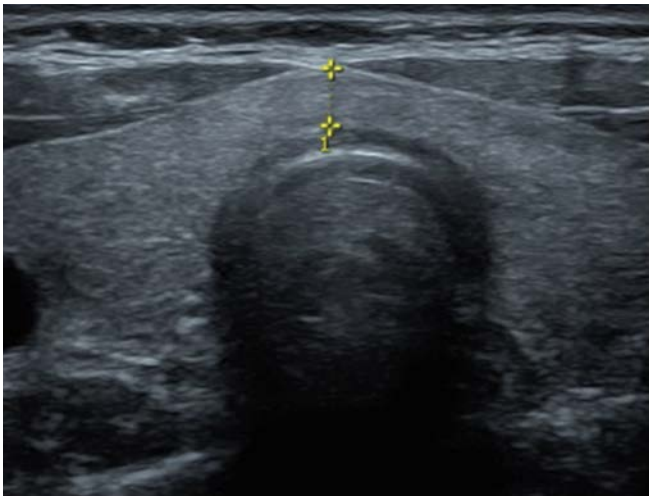

Fig. 2. *Scanogram showing the isthmus of the thyroid gland*

Determination of sample size

The sample size was determined using the formula below:[30]

$N = N/1 + N (e)^2$

Where n = sample size

N = finite population

e = level of significance or limit of tolerable error

1= unity (a constant)

The number of registered population in Nnewi was used as a yardstick to determine the sample size. According to Anambra State Statistical book 2011, the registered population in Nnewi was 79,925. According to Uzuagulu (1998), the level of significance used was 0.056[31]. Using these figures we calculated as follows:

$n = 79925/1 + 79925 (0.056)^2 = 318$

therefore, $n = 318$

Ethical consideration

Ethical approval was sought and obtained for this study from the Ethical Committee of the Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Nnewi Campus. A written consent form was provided to the subjects after appropriate explanation of the research procedures. These forms were signed by the patients who agreed to participate in the study. They were informed about the possibility to withdraw from the study at any time and without any adverse consequences.

Inclusion and exclusion criteria

Those included in this study had no medical history of thyroid enlargement or thyroidectomy. Patients with thyroid enlargement and/or with a history of thyroidectomy were excluded from the study.

Thyroid gland scanning technique

The patients were placed in a supine position with their heads extended and necks hyperextended with a pillow under their shoulders to keep them in this position. The thyroid gland is a superficial organ and requires appropriate equipment with a linear high frequency transducer (7.5–12 MHz)[32]. A 7.5 MHz linear transducer with a long footprint was used to scan the thyroid glands in transverse and longitudinal directions. The linear transducer used was from a 2-dimensional ultrasound machine; model Siemens Sonoline Prima which was made in Japan for Siemens Medical System Incorporated, ultrasound Group, Issaquah, WA, 98029-7002, USA. The sternal notch and the top of the thyroid cartilage were used as the external scanning landmarks. The internal landmarks used were the common carotid artery and internal jugular vein, the trachea, cervical spine and the posterior and anterior muscle groups of the neck.

Before scanning, necklaces and other clothing materials were removed from the necks of the subjects to avoid opacity. The scanning commenced with a liberal application of ultrasound coupling gel over the area of the neck around the thyroid cartilage (Adam's apple). Transverse scans were traditionally performed first, starting with the right lobe. The subject's head was turned slightly away to the left for the right lobe scan and to the right for the left lobe scan. This was performed to get the mandible out of the way. Each lobe was scanned in the transverse plane from the most inferior extent to the most superior extent with the transducer held at a ninety degree angle (90°) across the gland. The gland was identified as homogeneously echogenic tissue. The internal jugular vein lies laterally to the gland while its posterior margin is defined by the common carotid artery. The sternocleidomastoid, sternohyoid and sternothyroid muscles are anterior and lateral to the gland. The widest mediolateral width of the organ was sought and viewed on a frozen image. On the same image, the breadth (anteroposterior) span was sought at ninety degrees (90°) to the plane of previous image (mediolateral span). For the longitudinal scan, the transducer was placed at the point where the mediolateral and anteroposterior (AP) scans were taken.

The transducer was then turned through 90° to lie longitudinally over the gland. The longest craniocaudal span was then viewed.

The isthmus was identified as an isotropic narrow band of tissue running over the trachea and connecting the right and left glands. The above scanning technique was performed on individual lobes of the thyroid glands of each subject to determine the presence of any observable variations in the morphology of the thyroid glands (see Fig. 1 and Fig. 2 for ultrasound scans showing the depth of the thyroid gland, the left and right lobes of the thyroid gland and the isthmus of the thyroid gland respectively).

Method of data analysis

All collected data were analyzed statistically using Statistical Package for Social Sciences (SPSS) version 20.0.

The SPSS was used to calculate the mean, standard deviation, independent t-test and simple percentage. The level of significance was fixed at 5% (0.05) and the difference between the tests was considered significant at $p < 0.05$.

Results

The age of patients ranged from 18 years to 35 years (Tab. 1). The highest number of the subjects were aged 18 to 23 years, with 49 (29.8%) males and 125 (79.6%) females, while the lowest number of subjects were aged 30 to 35 years, with 28 (17.1%) males and ten 10 (6.4%) females. Most of our participants were students.

Table 2 shows that the mean age ranged between 21.47 and 33.32 years for men and between 20.85 and 31.80 years for women. The mean age of males was 25.86 years with a standard deviation of 4.24 and the mean age of females was 22.24 years with a standard deviation of 3.43. Independent sample t-test revealed that men had significantly higher age than their female counterparts ($p < 0.05$) in all age groups except for the age group 24–29 years, where it was insignificant ($p > 0.05$). The independent sample t-test also revealed that the total mean age of males was significantly higher than that of their female counterparts ($p < 0.05$). However, the total mean age of the subjects was 24.09 years with a standard deviation of 4.26.

Table 3 shows that there was no observed morphological anomaly of the thyroid glands. This indicates that there was no incidence of the pyramidal lobe (0%) and no incidence of (total or partial) agenesis of the isthmus (0%).

Discussion

There have been reports indicating that developmental anomalies of the thyroid gland are quite commonly seen[28]. Melnick *et al.* also reported that most of the variations in thyroid gland were due to the partial persistence of the median or thyroglossal cysts[33]. Persistence of pyramidal lobe, thyroglossal cysts, agenesis of the thyroid gland and aberrant thyroid gland are the major developmental anomalies of the thyroid gland[34,35].

Our study showed that there was no incidence of agenesis of isthmus or the presence of pyramidal lobe in the study population. This is in contrast with an ultrasonic study on the incidence and morphological features of the pyramidal lobe of thyroid gland conducted by Mortensen *et al.*[22] at Bristol, United Kingdom. They observed that out of the total number of subjects examined, a pyramidal lobe was found in 21% (90/416). They also reported that 51% (46/90) of the pyramidal lobes were observed to originate from the right of the isthmus, 46% (41/90) from the left of the isthmus and 2% (2/90) from the midline. Mortensen *et al.*,[22] also reported that one patient was observed to have two pyramidal lobes. The present study is also in contrast with the study of anatomical and morphological variations of the thyroid gland conducted by Reddy and Panchakshari[36] at Nagunur, Karimnagar, Telangana. Using ultrasound, they found normal thyroid structures in 72.1% (103/143) of the subjects. They also found thyroid gland accessory tissue (pyramidal lobe) to be present in 21.7% (31/143) of the subjects. Also, they observed thyroid gland with ectopic tissue (lingual thyroid) in 2.1% (3/143) of the subjects. Equally, they reported the presence of ectopic tissue (sublingual thyroid) in 0.7% (1/143) and thyroglossal duct cyst in 2.7% (4/143). In addition, the present study does not correspond with the results of a clinical study of the pyramidal lobe of the thyroid gland in patients undergoing total thyroidectomy, which was conducted by Emin *et al.* at Duzce, Turkey[37].

Age (years)	Males	Females	Total
18–23	49 (29.8%)	125 (79.6%)	174
24–29	87 (53.1%)	22 (14%)	109
30–35	28 (17.1%)	10 (6.4%)	38
Total	164	157	321

Tab. 1. *Age and sex distribution of the subjects*

	Age groups (years)			
	18–23	**24–29**	**30–35**	**Total mean**
Males (years) ± SD	21.47 ± 1.31	25.93 ± 1.68	33.32 ± 1.87	25.86 ± 4.24
Females (years) ± SD	20.85 ± 1.60	25.77 ± 1.69	31.80 ± 1.55	22.24 ± 3.43
***t*-value**	2.417	0.393	2.520	8.408
***p*-value**	0.017*	0.697	0.021*	0.000*
** significant*				

Tab. 2. *Descriptive characteristics of the age groups of male and female subjects*

Morphological anomaly	Number of subjects	Percentage (%)
Pyramidal lobe	Nil	0
Total agenesis of the isthmus	Nil	0
Partial agenesis of the isthmus	Nil	0

Tab. 3. *Incidence of the pyramidal lobe and agenesis of the isthmus*

They showed the incidence of pyramidal lobe of 65.7%. They also observed that the base of the pyramidal lobe was located at the isthmus in 52.3%, the left lobe in 29.4% and the right lobe in 18.3% of the subjects. Our findings are also in contrast with the cadaveric study conducted by Tanriover *et al.* in Turkish patients[29]. They found pyramidal lobe to be present in 57.8% of the cadavers (52/90); 47.8% of the male cadavers showed a pyramidal lobe while it was found in 10% of the females. They also reported an incidence of 2.22% agenesis of the isthmus of the thyroid gland and one of the pyramidal lobes extended from the midline and crossed over the right side. The findings of this study are also contrary to the post-mortem anatomical study with clinical implications conducted in Serbia and assessing the pyramidal lobe of the human thyroid glands. Milojevic *et al.* found a pyramidal lobe in 55.2% of cases[19]. Also, our study does not correspond with the study by Daksha *et al.* on the agenesis of the thyroid isthmus in adult human cadavers: a case series in Belgaum Karnataka, India[23]. They found that during midline dissection of the neck, 14.6% of the cadavers dissected showed no glandular tissue in the region of the isthmus of thyroid gland. They also stated that the agenesis of isthmus can be explained as an anomaly of embryological development i.e. a high division of the thyroglossal duct giving rise to two independent thyroid lobes with absence of the isthmus[23]. Another study on morphological variations of the thyroid glands of cadavers in Kanchipuram conducted by Kafeel *et al.*[38] is contrary with the present findings on the normal morphology of the thyroid gland. They observed the presence of pyramidal lobes in 40.6% of the cadavers. They also showed the absence of isthmus in 6.2% of the cadavers, with the levator glandular thyroidea extending from the right lobe to the thyroid cartilage in one of them. They also revealed that 25% of the cadavers showed the presence of a thin and fibrous Levator Glandulae Thyroidea (LGT) of which 12.5% were arising from the pyramidal lobe and 9.4% from the right lobe. Interestingly, they observed the presence of two LGTs in 3.1% of the cadavers[38].

Furthermore, the present study which revealed no incidence of agenesis of isthmus or the presence of pyramidal lobe in the thyroid gland in the study population is in variance with the cadaveric study conducted by Hussein *et al.*[39] and concerning anatomical variations of the thyroid gland and their clinical significance in Nagar population of Northern India. They reported that out of 56 cadavers, pyramidal lobe was observed in 41.0% of male cadavers, but was absent in female cadavers. They also revealed the presence of levator glandular thyroideae in 19.6% of the cadavers, with only 3.5% in female cadavers. The authors also observed the absence of isthmus in 12.5% of the cadavers, 3.5% females[39].

Also, our findings are in contrast with a cadaveric study on anatomical variations in the thyroid gland conducted by Deepa and Shrikrishnaat Raichur, Karnataka, India. They found agenesis of isthmus in 5% of the cadavers which also showed pyramidal lobe arising from right lobe. They also reported that 20% of the cadavers showed partial agenesis of thyroid isthmus. Furthermore, a pyramidal lobe was observed in 25% of the cadavers, out of which 15% were seen to be arising from the left lobe; 5% of the cadavers showed pyramidal lobe on right side which was associated with agenesis of isthmus[28]. The pyramidal lobe should not be overlooked due to its common occurrence and a varying extent as a potential risk for recurrence after surgery[40]. Therefore, surgeons should carefully investigate the thyroid tissue and the whole anterior neck region in detail[40]. De Felice and Di Lauro reported that genetically determined agenesis results from mutations in one of these developmental genes (TITF1, PAX8, FOXEI/TITF2), especially TITF2 since these genes are more essential for normal development of the palate and the thyroid gland[41]. In addition, agenesis of the isthmus can be explained as an anomaly of embryological development, i.e. a high division of the thyroglossal duct which gives rise to two independent thyroid lobes with the absence of isthmus[42]. According to Keith and Arthur, the pyramidal lobe develops from the remnants of the epithelium and connective tissue of the thyroglossal duct[34]. However, the identification and removal of the pyramidal lobe are also of great importance for successful postoperative radioactive iodine treatment in patients with differentiated thyroid carcinoma[38].

The present study has revealed that there were no cases of the agenesis of the isthmus and presence of the pyramidal lobe in the study population. This indicates that none of these patients had a mutation in any of the developmental genes necessary for normal development of the palate and thyroid gland. Also, there were no remnants of the epithelium and connective tissue of the thyroglossal duct which leads to the development of pyramidal lobe. The observed variations between the findings of the present study and previous studies could be attributed to racial and geographical factors or deviations from normal embryological developmental process.

Conclusion

The exact knowledge and understanding of thyroid anatomy and its variation with associated anomalies are very essential for surgical interventions. This study has clearly revealed no incidence of the pyramidal lobe and agenesis of the thyroid isthmus among the residents of Nnewi, Nigeria.

Conflict of interest

There is no conflict of interest.

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