

The Incidence of the Foramen Thyroideum in the South African Population

Incidencia del Foramen Tiroideo en la Población de Sudáfrica

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RAMSAROOP, L.; HURRINARAIN, K.; PARTAB, P. & SATYAPAL, K. S. The incidence of the foramen thyroideum in the South African population. *Int. J. Morphol.*, 28(2):433-438, 2010.

SUMMARY: The foramen thyroideum is described as an occasional opening existing in one or both laminae of the thyroid cartilage which may or may not contain a neurovascular component. Foramen thyroideum was first described in the literature by Segond in 1847. Some authors consider its existence a structural variation rather than an anomaly, with classical texts of anatomy providing little detail when describing this foramen. This study was undertaken to investigate the incidence and characteristics of the foramen thyroideum in the South African population. A total of 80 formalin fixed cadaveric laryngeal specimens (obtained from the Department of Clinical Anatomy, University of KwaZulu-Natal, South Africa) were dissected. Larynges were dissected with the aid of a Stemi DV 4 light microscope. The incidence, location, dimensions and contents of the foramen thyroideum were recorded. The horizontal and vertical extent of each foramen was measured with a digital caliper. Six of the 80 (7.5%) specimens examined had distinctly identifiable foramina. Five of the six cases (4 male, 1 female) displayed bilateral foramina (6.3%), with one case (1 female) of a unilateral foramen (1.3%). Of the larynges that had bilateral foramina, a single case presented with two foramina on the same (right) thyroid lamina. A total of twelve foramina were observed. Gender distribution of foramen thyroideum was: male: right 5, left 4; female: right 2, left 1. Preceding investigators of the foramen thyroideum have rightly indicated that awareness of its presence is of paramount importance in order to preserve the structures that traverse it and also to comprehensively treat or contain laryngeal cancer.

KEY WORDS: Thyroid; Foramen; Larynx; Variation.

INTRODUCTION

Foramen thyroideum (FT) has been described as an occasional opening existing in one or both plates of the thyroid cartilage which may or may not contain a neurovascular component (Zemlin *et al.*, 1984). Although first described in 1847 by Segond (Leon *et al.*, 1997), it remains a contentious issue as some consider its existence a routine structural variation rather than an anomaly (Ortug *et al.*, 2005), with classical texts of anatomy not delving into great detail when providing an account on FT (Friel, 1974; Williams *et al.*, 1989; McMinn, 1990).

Previous investigations have yielded either unilateral or bilateral occurrence of the FT (Leon *et al.*; Ortug *et al.*) that extend over a wide range (Leon *et al.*) with reports of more than one foramen on the same thyroid lamina (Ortug *et al.*) also having been recorded. The literature also demonstrates cases in which the FT functions as a unique conduit for branches of the superior laryngeal nerve (Tanaka *et al.*, 1997)

as well as the superior laryngeal artery and vein (Zemlin *et al.*). It has been hypothesized that the foramen may also provide a pathway for adenocarcinoma and pyriform recess or transglottic tumors (Kirchner *et al.*, 1989) but remains as resistant to laryngeal cancer as the rest of the thyroid lamina.

To our knowledge, no investigations systematically evaluating the incidence of the FT or comparing their characteristics and emphasizing their clinical significance have been previously published on the South African population, thus highlighting a need for such a study.

MATERIAL AND METHOD

The study comprised a sample size of 80 formalin fixed laryngeal specimens (a total of 160 thyroid laminae)

which were sourced with approval from the State Mortuary, Gale Street, Durban, South Africa and the research conducted at the Department of Clinical Anatomy, University of KwaZulu-Natal. The sample size was decided upon bearing in mind a statistically significant cell size as well as access and availability of specimens. Ethical approval for this study was granted by the Institutional Biosafety and Research Committee of the University of KwaZulu Natal. The sex distribution of the specimens were 46 male (58%) and 34 were female (42%). The age range was between 43 years to 81 years for male and 55 years to 73 years for female. Standard anatomical micro-dissection techniques were employed to dissect the larynges with the aid of a Stemi DV 4 light microscope (Carl Zeiss Inc, Germany). Specimens that had been previously dissected, deformed due to trauma or had evidence of pathology were excluded from the study. The incidence, location, dimensions and contents of the foramen thyroideum were recorded. The horizontal and vertical extent of each foramen was measured by means of a digital caliper (Digitronic caliper; Wolpert Europe; Maastricht, Netherlands). Statistical analysis was conducted with the statistical package SPSS using the Binomial Two Proportion Test (for differences in counts).

RESULTS

Incidence. Six of the 80 (7.5%) specimens examined had distinctly identifiable foramina (Table I). Five of the six cases (4 male, 1 female) displayed bilateral foramina (6.3%) (Fig. 1), with one case (1 female) of a unilateral foramen (1.3%) (Fig. 2). Of the larynges that had bilateral foramina, a single case presented with two foramina on the same (right) thyroid lamina, separated by only a thin band of cartilage

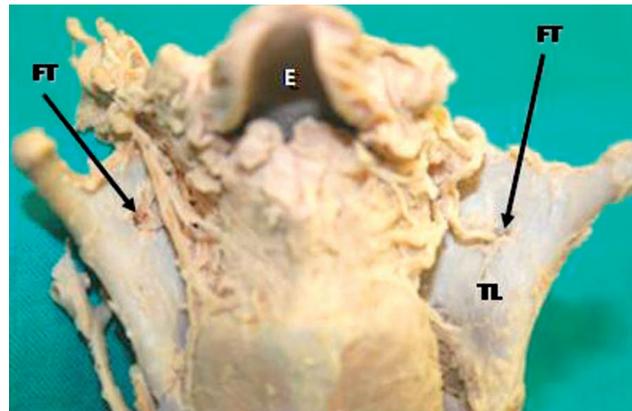


Fig. 1. Posterior view of thyroid lamina illustrating bilateral FT with anastomotic connection between external and the internal laryngeal nerves. E=Epiglottis.

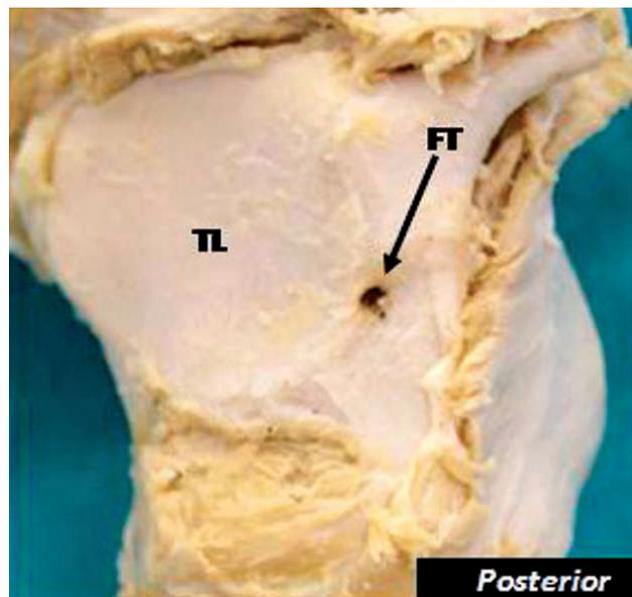


Fig. 2. FT in left thyroid lamina on oblique line.

Table I. Incidence of foramen thyroideum in the literature reviewed.

Author(s)	Population group	Sample Size	Number	Incidence (%)
Gruber (1876)	German	170	71	48
Dilworth (1921)	British	23	4	17.3
Waldeyer (1927)	German	100	55	55
Roncallo (1948)	Italian	57	3	5.2
Guerrier & Prioton (1954)	French	94	24	26
Keen & Wainwright (1958)	South African	133	23	17
Afifi (1970)	French	16	7	44
Jelisiejew & Szmurlo (1972)	Polish	484	184	38
Lang <i>et al.</i> (1984)	German	22	6	27
Zemlin <i>et al.</i> (1984)	American	66	22	33
Kirchner <i>et al.</i> (1989)	American	190	86	45
Leon <i>et al.</i> (1997)	Spanish	90	28	31
He <i>et al.</i> (1999)	French	50	1	2
Ortug <i>et al.</i> (2005)	Turkish	50	6	12
Cicekcibasi <i>et al.</i> (2008)	Turkish	40	5	12.5
Ramsaroop <i>et al.</i> (2009)	South African	80	6	7.5

(Fig. 3). A total of twelve foramina were observed. The incidence of FT in individual sexes were as follows: male: right 5, left 4; female: right 2, left 1 (Table II). No statistically significant differences between sexes or sides were noted.

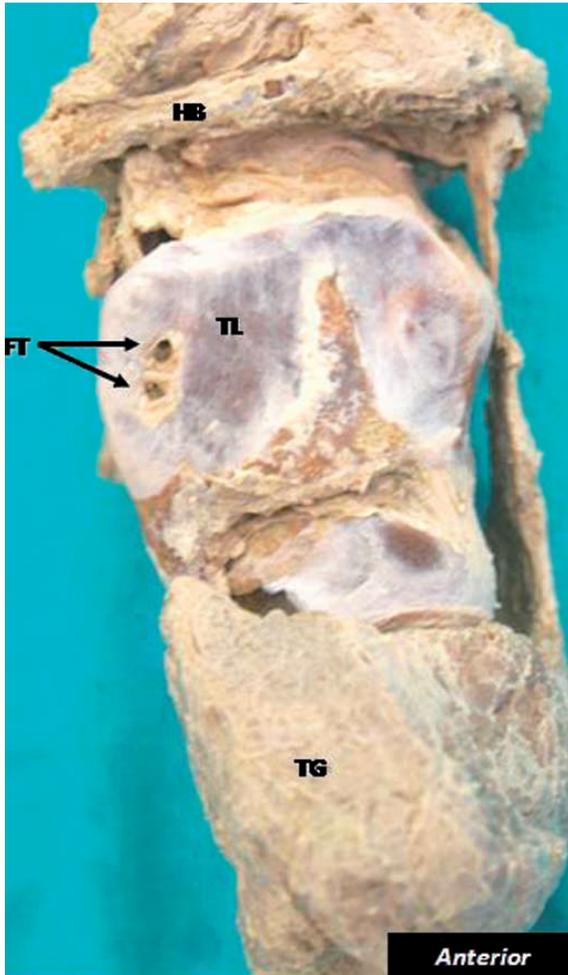


Fig. 3. Lateral view of double FT in the right thyroid lamina. HB=Hyoid bone, TG=Thyroid gland.

Morphology. Six foramina were oval in shape; while six were almost perfectly round in shape. No statistically significant differences were noted.

Location. The locations of the foramina were identified in relation to the oblique line of the thyroid lamina. Eight of the foramina were situated anterior to the oblique line (Fig. 4) with a mean distance of 1.8mm (range: 0.93mm - 2.32mm); two were located posterior to the oblique line (Fig. 3) with a mean distance of 1.9mm (range: 1.5mm - 2.4mm) and two were located on the oblique line (Fig. 2) (Table III). The single case of double foramina on the right thyroid lamina was located posterior to the oblique line, facing posteriorly (Fig. 3).

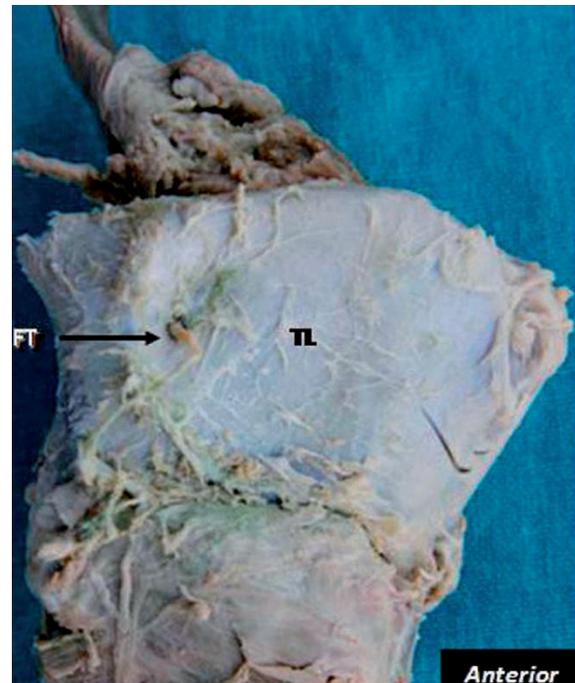


Fig. 4. Lateral view of FT situated anterior to oblique line. Note: Exit of internal laryngeal nerve via FT. TL=Thyroid lamina, FT=Foramen thyroideum.

Table II. Sex distribution of foramen thyroideum in the literature reviewed.

Author	Male	Female	Unknown
Zemlin <i>et al.</i> (1984)	8	13	1
Ortug <i>et al.</i> (2005)	6	0	0
Ramsaroop <i>et al.</i> (2009)	9 (5 right, 4 left)	3 (2 right, 1 left)	0

Table III. Location of foramen thyroideum in relation to oblique line (n=12). Please note: Authors describing FT in relation to the oblique line only, without providing mean distances, is shown in brackets

Location on thyroid lamina	Mean distance (mm)	Range (mm)
Anterior to oblique line (n=8) (Ortug <i>et al.</i> 2005)	1.8	0.9 - 2.3
Posterior to oblique line (n=2) (Keen & Wainwright, 1958; Zemlin <i>et al.</i> , 1984; Leon <i>et al.</i> , 1997)	1.9	1.5 - 2.4
On oblique line (n=2)	-	-

Measurements. The mean horizontal and vertical diameters (mm) of the FT was found to be 2.9mm and 3.1mm; and 2.8mm and 2.6mm on the right and left sides, respectively (Table IV).

Contents. All twelve foramina contained an anastomotic connection between the external laryngeal nerve and the internal laryngeal nerve. In addition, a neural connection

between the external laryngeal nerve and the recurrent laryngeal nerve via the FT was observed in one case. In the thyroid cartilage displaying two foramina on the right side, two separate connections between the external laryngeal and internal laryngeal nerves via their respective foramina were noted. In two cases FT was also traversed by the superior laryngeal artery.

Table IV. Measurements of foramen thyroideum.

Diameters (mm)	Horizontal		Vertical	
	Right	Left	Right	Left
Mean	2.9	2.8	3.1	2.6
Min	2.3	2.3	2.5	2.2
Max	4.3	4.1	3.9	3.3

Table V. Size of foramen thyroideum in literature reviewed. *Measurements in individual sexes not available.

Author (s)	Measurement range (mm)
Gruber (1876)	0.5 – 9*
Afifi (1970)	2.5*
Lang <i>et al.</i> (1984)	2.5-4*
Zemlin <i>et al.</i> (1984)	0.45-6.5 (female); 0.5-6 (male)
Ramsaroop <i>et al.</i> (2009)	Horizontal : 2.3-4.3 (female); 2.2-4.1 (male) Vertical: 2.2-3.2 (female); 2.2-3.9 (male)

DISCUSSION

Previous studies have indicated a wide range in incidence of FT of between 2% to 55% (Table I). Our data illustrates an incidence of 7.5% which compares with only one previous investigation – viz. Roncallo (1948). Furthermore, only two previous studies describe the sex distribution (Table II); Zemlin *et al.* noted a higher incidence in females whereas Ortug *et al.* and our study recorded the opposite.

Developmentally, two theories have been proposed to explain the derivation of the FT. The first is the branchial origin where the FT is considered to be an incomplete union of the cartilaginous elements of the fourth and sixth pharyngeal arches which give rise to the thyroid lamina. The second is the neurovascular theory which postulates that the presence of a vessel or nerve in the lamina of the thyroid cartilage during the embryonic period resulting in failure of chondrification, thus the formation of the FT (Leon *et al.*); however consideration should be given to the possibility that failure of coalescence of the fourth and sixth branchial arches and the presence of abnormal nervous or mesenchymal growth appear to be two processes that are intimately connected with one another and that failure on either end

could lead to abnormal growth in either direction (Leon *et al.*). Our data supports the latter theory where all twelve foramina contained a neural component which consisted of an anastomotic connection between the external and internal laryngeal nerves. These results compare favourably with that of Leon *et al.* In two of the twelve cases, the FT contained the superior laryngeal artery confirming reports by Zemlin *et al.*

In contrast to the study conducted by Ortug *et al.* on the Turkish population, our study revealed a higher incidence of bilateral FT (6.3%) compared to their study of 2%. In addition, a unilateral foramen in our study was noted in only 1 case (1.3%) on the right side, which differs from previous researchers (Afifi, 1970; Zemlin *et al.*; Leon *et al.*) who record that unilateral FT appear to be located more frequently on the left side.

Our study also records the presence of a double FT on the right side, with the upper FT being larger than the lower. These results compare favorably with those of Gruber (1876) as well as Leon *et al.* who reported two and three cases of double FTs, respectively.

The measurements of the size of the FT compare favorably with that of Afifi and Lang *et al.* (1984) (Table V). However, only the study conducted by Zemlin *et al.* described the measurements of FT in males and females, which differed to our study which documents the diameter ranges for males and females of FT viz. horizontal diameter 2.2mm - 4.1mm and 2.3mm - 4.3mm; and vertical diameter 2.2mm - 3.9mm and 2.2mm - 3.2mm, respectively (Table V).

Preceding investigators of the FT have rightly indicated that awareness of its presence is of paramount importance in order to preserve the structures that traverse it and also to comprehensively treat or contain laryngeal cancer (Ortug *et al.*). From the results obtained in this study, it can

be clearly demonstrated that the incidence of the FT in the South African population is less frequent, and with no gender dimorphism as compared to studies conducted in European population groups; however the location, size and contents are comparable and its clinical importance should not be neglected. Iatrogenic injury of the inferior laryngeal nerve, terminal portion of the recurrent laryngeal nerve (Reidenbach, 1995), is one of the most crucial concerns during thyroid surgery where paralysis of the vocal cords may be an inadvertent complication. This causes significant phonatory, respiratory and psychological problems that may impact on patient lifestyle (Dilworth, 1921). The operating surgeon, therefore, should exercise added vigilance when performing interventional surgery in order to prevent avoidable injury.

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RESUMEN: El foramen tiroideo se describe como una apertura ocasional existente en una o ambas láminas del cartílago tiroideo, la cual puede o no contener un componente neurovascular. El foramen tiroideo fue descrito por primera vez en la literatura por Segond en 1847. Algunos autores consideran su existencia como una variación estructural y no una anomalía, los textos clásicos de anatomía proporcionan pocos detalles al describir este foramen. Este estudio se realizó para investigar la incidencia y características del foramen tiroideo en la población Sudafricana. Fueron disecados 80 especímenes cadavéricos de laringe fijados con formalina (obtenidos del Departamento de Anatomía Clínica de la Universidad de KwaZulu-Natal, Sudáfrica). Las laringes fueron disecadas con la ayuda de un microscopio de luz Stemi DV 4. La incidencia, localización, dimensiones y contenido del foramen tiroideo fueron registradas. La extensión horizontal y vertical de cada foramen se midieron con un caliper digital. Seis de los 80 (7,5%) especímenes examinados tenían foramen tiroideos claramente identificables. Cinco de los seis casos (cuatro hombres y una mujer) mostraron forámenes bilaterales (6,3%), y un caso (una mujer) foramen unilateral (1,3%). De las laringes que presentaron forámenes bilaterales, un solo caso presentó dos forámenes en la misma lámina del cartílago tiroideo (derecha). La distribución por sexo del foramen tiroideo en hombres fue 5 derechos y 4 izquierdos, mientras que en mujeres 2 derechos y 1 izquierdo. Los resultados indican que el conocimiento de la presencia del foramen tiroideo es de vital importancia para preservar las estructuras que lo atraviesan y también para el tratamiento de integral o contención del cáncer de laringe.

PALABRAS CLAVE: Tiroides; Foramen; Laringe; Variación.

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Received: 25-11-2009

Accepted: 11-03-2010