

Anatomical and Clinical Relevance of the Thyroid Foramen

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ABSTRACT

Objective: The thyroid foramen (TF) is an opening on the lamina of the thyroid cartilage. It may be located on the posterosuperior part of the lamina or below the superior tubercle. The aim of the present study was to determine the incidence of the foramen in an adult Turkish population and the morphometry, topography, and structures within it, thereby aiding surgeons working in this area. **Methods:** In 57 formalin-fixed cadaveric laryngeal specimens, 113 (56 right and 57 left) sides were dissected using a surgical microscope.

Results: The TF was observed in 6 out of 57 (10.5%) specimens. It was bilateral in 3 (5.3%) specimens; thus, it was observed in 9 sides. It was located at (33.3%) or posterior to (66.7%) the oblique line and below the superior tubercle. It was crossed by only a nerve in 2 (22.2%) left sides, an artery with a vein in 2 (22.2%) sides, or a neurovascular bundle in 5 (55.6%) sides.

Conclusion: The TF is a variation located on the lamina of the thyroid cartilage with an incidence of 2% to 57% in adults. Neurovascular structures can pass through it. It is important in two aspects: surgical exposure and spread of laryngeal tumors.

Keywords: Thyroid cartilage, thyroid foramen, superior laryngeal nerve

INTRODUCTION

The thyroid cartilage is the most prominent cartilage of the larynx. It consists of two hyaline cartilage flats called laminae. The apparent protrusion of the anterior fusion of these laminae is called laryngeal prominence. On the lateral side of each lamina, a slight crest extending from the superior thyroid tubercle to the inferior thyroid tubercle is called the oblique line. The posterior borders of the laminae do not fuse and deviate laterally. The superior and inferior extensions seen on the posterior border are called superior and inferior cornu (1).

The thyroid foramen (TF) is an opening located in one or both posterosuperior parts of the lamina of the thyroid cartilage and below the superior tubercle. Its presence over the thyroid cartilage lamina becomes apparent from the middle of the first trimester and closes during the subsequent trimesters. If there is a problem at the conjunction point of the cartilage tissue between the 4th and the 6th pharyngeal arches, the foramen can remain open (2, 3). The incidence of the TF has been variously reported, ranging from 2% to 57% in adults (4, 5). It is sometimes double but is more often seen in single form (3, 6, 7). Its location has been reported as posterior or anterior to the oblique line and below the superior tubercle. The foramen might contain only a nerve or vessel or house a neurovascular bundle. The nerve anas-

tomoses between the external branch of the superior laryngeal nerve (ebSLN) and the internal branch of the superior laryngeal nerve (ibSLN) (3, 6–8) or between the ebSLN and the recurrent laryngeal nerve (9, 10). The arterial branch is usually an aberrant superior laryngeal artery (SLA) (3, 6, 9). The foramen is rarely covered only by the connective tissue with no content.

The TF is generally found incidentally during imaging examinations, larynx surgery or dissection of the neck. Its presence and content can be clinically important. Surgeons should be careful to avert from iatrogenic damage to the nerve or bleeding of the vessel when they place a surgical retractor or reflect the soft tissue around the larynx.

The aim of the present study was to determine the incidence of the TF in an adult Turkish population and the morphometry, topography, and structures within it, thereby aiding surgeons working in this area.

METHODS

The study was conducted with 57 formalin-fixed cadaveric laryngeal specimens. A total of 113 (56 right and 57 left) sides were investigated. Dissections were made using a Zeiss OpM1 surgical microscope (OpM1; Carl Zeiss, Oberkochen, Germany). One right

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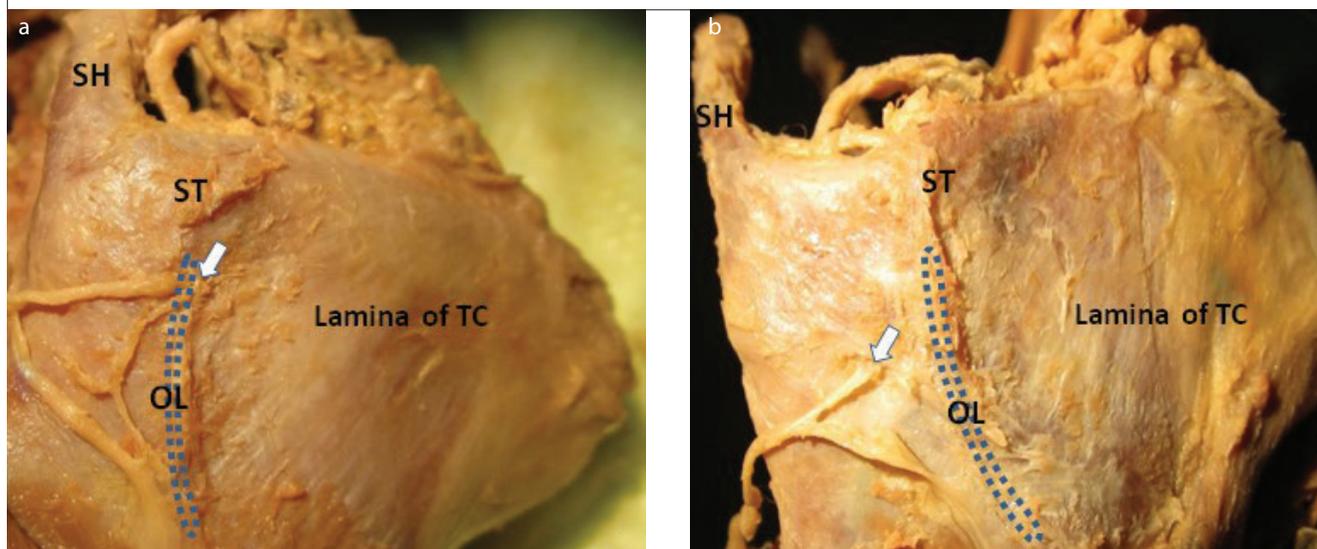
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Table 1. Mean values of the measurements of the TF (mm)

Vertical distance of the outer side of the foramen	Horizontal distance of the outer side of the foramen	Vertical distance of the inner side of the foramen	Horizontal distance of the inner side of the foramen	Distance between the superior tubercle and the TF
2.3±1.0	2.2±0.9	3.1±0.9	2.4±0.7	6.7±2.9

Figure 1. a, b. Right laminae of the thyroid cartilage. The thyroid foramen (white arrow) was located at (a) or posterior (b) to the oblique line. It was below the superior tubercle

TC: thyroid cartilage; OL: oblique line; SH: superior horn



side was not suitable for dissection. After the soft tissue around the larynx was removed, the strap muscles were exposed. The muscle parts attaching to the thyroid cartilage were incised to expose the lamina of the cartilage and TF clearly. The soft tissue occupying the outer and inner openings of the foramen and surrounding its content was also cleaned to measure its dimensions and to follow the contents to their origin points. The inferior constrictor muscle was subsequently incised at the midline to view inside the lamina of the thyroid cartilage. This enabled us to follow the contents throughout their length. The incidence, location, contents, and diameters of the TF were recorded. Finally, the structure was documented using a high-resolution photography. The vertical length of the TF was regarded as the widest site of the foramen. The horizontal length of the foramen was considered as the longest distance between the superior and the inferior edges of the foramen. Measurements were made using a digital vernier caliper (D&W Measuring-1kds15, China). The local ethics committee approved the study (University of Health Sciences, Gülhane School of Medicine-2016-16), patient approval was not necessary since the current study was conducted on cadaveric specimens.

Statistical Analysis

Descriptive analyses were made for all variables. Statistical results represented as mean ± standard deviation. Statistical analyses of data were performed using Statistical Package for the Social Sciences for Windows, version 16.0. (SPSS Inc.; Chicago, IL, USA), at a statistical significance set at p<0.05.

RESULTS

The TF was observed in 6 out of 57 (10.5%) specimens. It was bilateral in 3 (5.3%) specimens, suggesting that it was observed in 9 out of 113 (7.9%) sides. Table 1 shows the mean values of the horizontal and vertical diameters of the outer and inner openings of the TF and the distance between the superior tubercle and the TF.

The TF was located at (33.3%, Figure 1a) or posterior to (66.7%, Figure 1b) the oblique line and below the superior tubercle in all nine sides.

The foramen was crossed by only a nerve originating from the ebSLN. This was observed in 2 (22.2%, Figure 2a) sides. After passing, it anastomosed with the ibSLN in all 9 sides (Figure 2b). The foramen was also crossed by an artery with a vein observed in 2 (22.2%, Figure 3a) sides. The artery originated directly from the superior thyroid artery (STA). No SLA was observed. After passing through the foramen, the artery spread to the area supplied by the SLA (Figure 3b). Finally, the foramen was crossed by a neurovascular bundle observed in 5 (55.6%, Figure 4a) sides. The nerve of the bundle emerged from the ebSLN and anastomosed with the ibSLN in all cases. The artery of the bundle originated from the STA directly or from its glandular branches. After passing through the foramen, the artery anastomosed with the SLA. If no SLA was observed (in two sides), the area normally supplied by the SLA was supplied by the artery passing through the TF (Figure 4b).

Figure 2. a, b. (a) Outer and (b) inner surface of the right lamina of the thyroid cartilage. The thyroid foramen (white arrow) was crossed by only a nerve originating from the external branch of the superior laryngeal nerve. After passing, the nerve anastomosed with the internal branch of the superior laryngeal nerve

TC: thyroid cartilage; n: nerve; ebSLN: external branch of the superior laryngeal nerve; ibSLN: internal branch of the superior laryngeal nerve; SH: superior horn

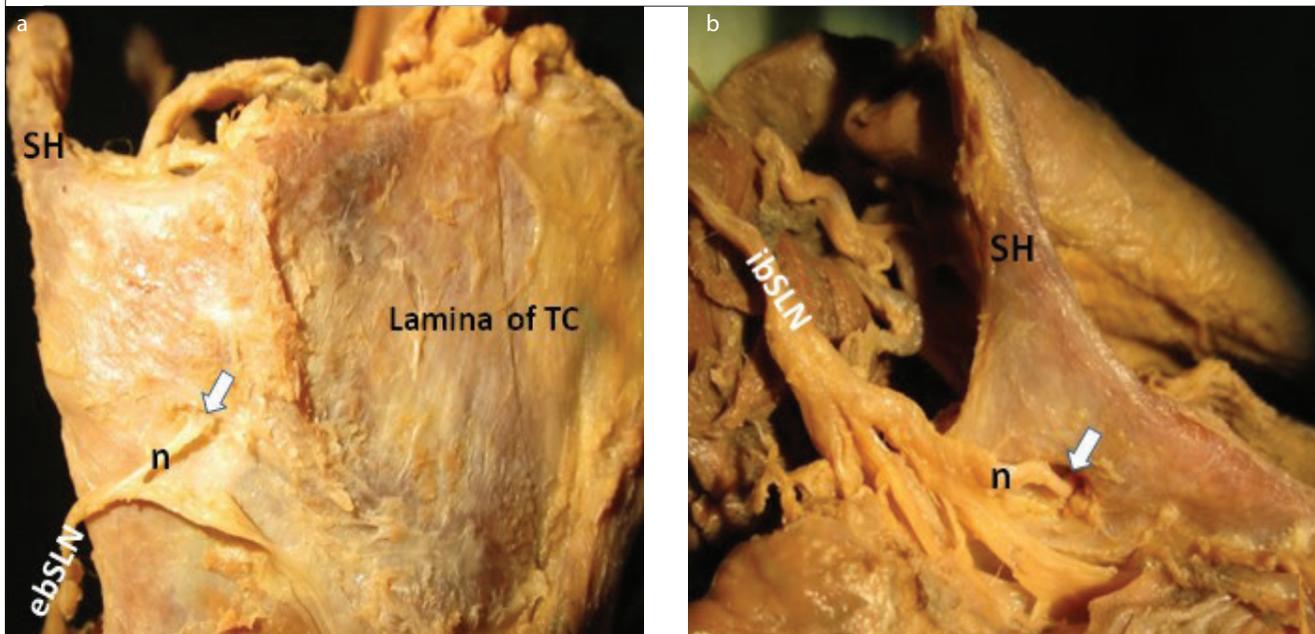
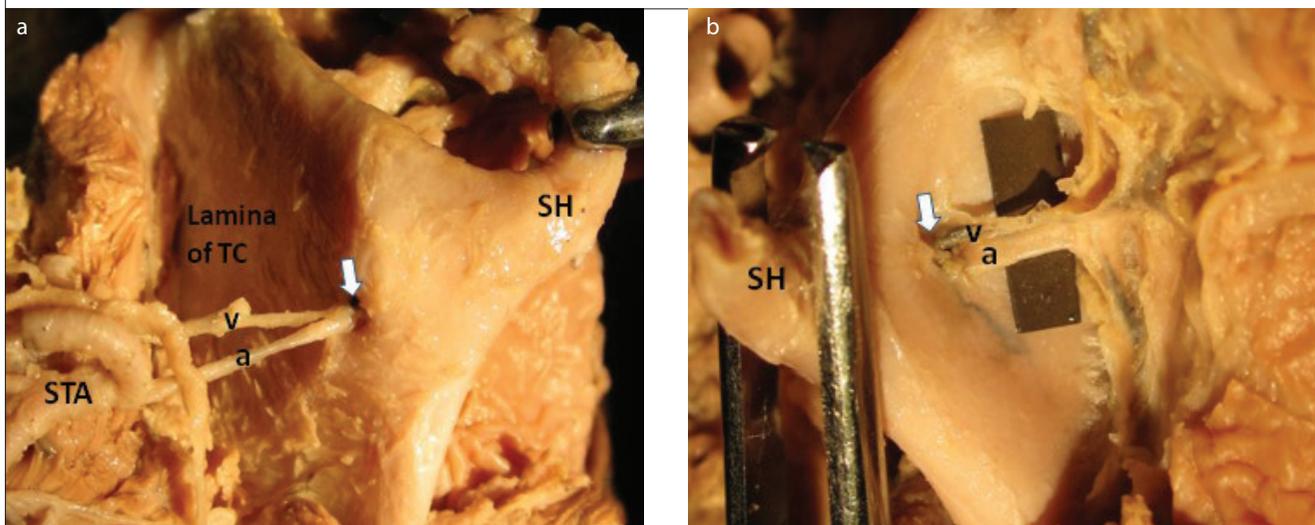


Figure 3. a, b. (a) Outer and (b) inner surface of the left lamina of the thyroid cartilage. The thyroid foramen (white arrow) was crossed by an artery with a vein. The artery originated directly from the superior thyroid artery

TC: thyroid cartilage; a: artery; v: vein; STA: superior thyroid artery; SH: superior horn



DISCUSSION

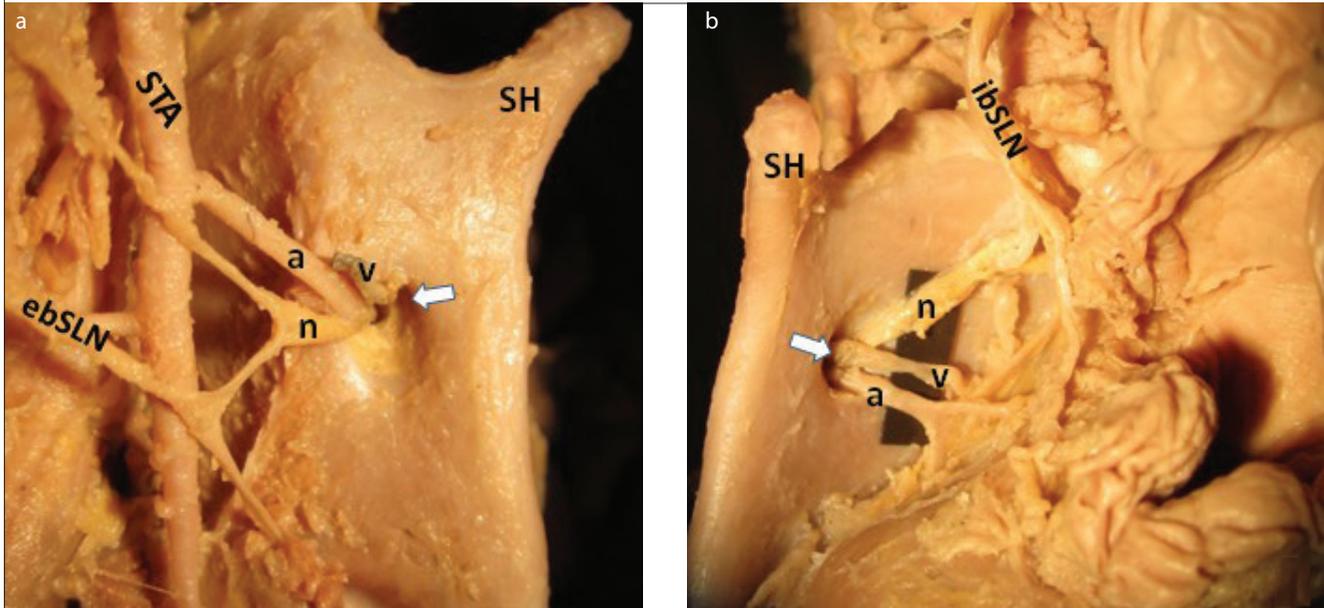
The embryological development of the TF is controversial. The embryonic draft of the thyroid laminae begins to develop in the first trimester as quadrilateral plates with a foramen. In the following stages of embryogenesis, the TF closes. However, hesitation or distortion of the fusion of the cartilaginous tissue between the fourth and the sixth pharyngeal arches may lead to the foramen to remain open (2, 3). Other studies have indicated that the shape of the TF is formed due to the content of the foramen, affecting the proper chondrification of the thyroid lamina

(6). This satisfactorily explains why the TF is almost always located on the posterosuperior aspect of the laminae, in the neighborhood of the superior thyroid tubercle (3, 6). Muller et al. (11) reported that the descent of the ebSLN over the thyroid cartilage during the development of the larynx results in the formation of the foramen.

This incidence of the TF has been variously reported as ranging from 2% to 57% in adults and from 12.5% to 76.9% in fetuses. Its incidence differs greatly among the adult population: 33%-57%

Figure 4. a, b. (a) Outer and (b) inner surface of the left lamina of the thyroid cartilage. The thyroid foramen (white arrow) was crossed by a neurovascular bundle. The nerve of the bundle emerged from the external branch of the superior laryngeal nerve and anastomosed with the internal branch of the superior laryngeal nerve. The artery of the bundle originated from the superior thyroid artery directly or from its glandular branches

TC: thyroid cartilage; n: nerve; ebSLN: external branch of the superior laryngeal nerve; ibSLN: internal branch of the superior laryngeal nerve; a: artery; STA: superior thyroid artery; SH: superior horn



in the USA, 2%–55% in Europe, 10%–16% in India, 27.3%–50% in Japan, and 7.5%–17.3% in South Africa (3). Ortug et al. (12) observed the TF in 12% of 50 Turkish cadavers, and it was found in 10.5% of 57 cadaveric laryngeal specimens in the present study.

The foramen appears solitary and unilateral in 0% to 42.9% of cases but bilateral in 0% to 31.3% (4, 9, 13). An equal incidence of the unilateral and bilateral TFs was also reported (3). There are few studies of double TFs in the literature (6, 7). There were bilateral TFs in 5.3% of specimens in the present study, but no double ones were observed.

The foramen was located posterior to the oblique line in 60% and 61.9%, at the oblique line in 14.3% and 20%, or anterior to it in 20% and 23.8% (3, 14). Ramsaroop et al. (7) stated that it was most often located anterior to the linea obliqua. It has also been reported as located below the oblique line in 68.29%, above it in 21.95%, and right at the upper end in 9.76% of cases (6). In the present study, it was found to be at the oblique line in 33.3% and posterior to it in 66.7%. It was located below the superior tubercle in all nine sides. The distance between the foramen and the superior tubercle was reported as 10 mm (9) and found to be 6.7 ± 2.9 mm in the present study.

The diameter of the TF ranged from 0.5 to 9 mm (3, 9). It was reported as 0.5–6 mm in males and 0.45–6.5 mm in females (15). The mean horizontal and vertical diameters were reported as 2.8 and 3.3 mm on the right side and 3.1 and 3.4 mm on the left side, respectively (14). According to our results, the outer vertical and horizontal diameters were 2.3 ± 1.0 and 2.2 ± 0.9 mm, respectively,

whereas the inner vertical and horizontal diameters were 3.1 ± 0.9 and 2.4 ± 0.7 mm, respectively.

The TF passed by neurovascular structures 6.5% to 83.3% was crossed by only a nerve originating from the ebSLN and anastomosing with the ibSLN inside the larynx (8, 12). In the present study, the same variation was observed in 2 (22.2%) sides. The TF passed by neurovascular structures 7% to 33% was crossed by only an artery, usually a communicating branch between the SLA and the cricothyroid vessels or an aberrant SLA (3, 6, 12, 16). In contrast, the TF was crossed by an artery with a vein in 2 (22.2%) sides. The artery originated directly from the STA. No SLA was observed. Since the artery spread to the area supplied by the SLA, it was regarded as an aberrant SLA. The TF passed by neurovascular structures 16.7% to 100% was crossed by a neurovascular bundle (4, 6–9, 12, 13). In the present study, a neurovascular bundle coursing through the TF was observed in 5 (55.6%) sides. Its nerve originated from the ebSLN and anastomosed with the ibSLN in all cases. Its artery originated from the STA directly (aberrant SLA) or from its glandular branches.

Partab et al. (10) reported an interesting case of double neural anastomosis running through the TF. In this case, two neural loops were observed. The proximal loop was reported to be between the ebSLN and ibSLN, whereas the distal loop was reported to be between the ebSLN and the recurrent laryngeal nerve.

The existence of the TF is most likely to be asymptomatic, but it is very significant in surgeries of the larynx, such as partial laryngectomy or partial reconstruction. Its location and contents

are important for surgeons performing laryngeal procedures (3). Since the artery passing through the TF supplies the area of the SLA when the SLA is absent, surgeons should remember the aberrant artery to avoid injury. Another way in which the TF is important concerns the spread of tumors: a TF containing neurovascular structures is a possible pathway for tumor spread (12).

CONCLUSION

The TF was observed in 6 out of 57 (10.5%) specimens. It was bilateral in 3 (5.3%) specimens. It was situated at (33.3%) or posterior to (66.7%) the oblique line and below the superior tubercle. The foramen was crossed by only a nerve (22.2%), only a vessel(s) (22.2%), or a neurovascular bundle (55.6%). The nerve extended between the ebSLN and the ibSLN in all cases. The artery originated from the STA directly or from its glandular branches. Surgeons should be aware of the unusual course of the neurovascular structures on the surface of the thyroid cartilage to avoid injuring the nerve and artery passing through the TF.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of University of Health Sciences, Gülhane School of Medicine (No: 2016-16).

Informed Consent: Informed consent was not necessary since the current study was conducted on cadaveric specimens.

Peer-review: Externally peer-reviewed.

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