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Primary schwannoma of the thyroid gland: analysis of case characteristics and review of the literature

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Abstract

Background To improve the characteristics of primary thyroid schwannomas (PTS) and to provide reference basis for clinical diagnosis and treatment.

Methods PubMed was searched for case reports of PTS up to December 2022 using the search terms "Thyroid nerve sheath tumor" or "Thyroid schwannoma" or "Thyroid Neurilemmoma", respectively. 34 cases were screened.

Results PTS can occur at any age, nodules averaged 3.9 cm. The most common symptoms were voice change and dysphagia. Fine needle aspiration cytology showing spindle-shaped cells should be considered for schwannoma. Most cases underwent thyroid lobectomy or nodule removal with a good prognosis. Tissue types with both Antoni A and Antoni B features are common. Positive immunohistochemical staining for S-100 protein, CD34 and waveform proteins helped confirm the diagnosis.

Conclusions Positive immunohistochemistry for S-100 and wave proteins helps confirm the diagnosis. Preoperative diagnosis is challenging, but pathology and immunohistochemical staining are the gold standard for diagnosis. The first choice of treatment is surgical resection of the nodules, the prognosis is good.

Keywords Thyroid schwannoma, Thyroid nerve sheath tumor, Neck schwannoma, Thyroid nodule, S-100 protein

Introduction

Schwannomas, also known as neuromas, neurinomas, or neurilemmomas, are slow-growing, benign tumors that may originate from peripheral nerves or nerve root sheaths covered by the sheath throughout the body. The schwannomas arise from neuronal sheath cells (also referred to as Schwann cells). During embryonic development, neural crest progenitor cells, which migrate along with the growing peripheral nerves and eventually develop into adult myelin or non-myelin Schwann cells, serve as the source of Schwann cell precursors. [1] Schwannomas are relatively rare, occurring mainly in the head, neck or extremities, with isolated or multiple lesions. [2] Although they are somewhat frequent in the head and neck, where they account for 25–45% of schwannomas, schwannomas involving the thyroid are exceedingly uncommon, [3] making for less than 0.02% of all thyroid tumors. [4] The first case report of primary thyroid schwannoma was reported by Delaney and Fry in 1964, similar to a benign thyroid nodule. [5] Primary thyroid schwannoma has been reported worldwide, most of them occurring in the age range of 40–60 years, [6] with around 40 cases reported to date. The sonographic

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features and clinical signs of primary thyroid nerve sheath tumors are close to those of thyroid nodules, making them difficult to differentiate from thyroid nodules and challenging to diagnose pre-operatively, thereby contributing to improper treatment. In this study, we analyzed the case characteristics of primary thyroid nerve sheath tumors and reviewed the correlation literature to improve clinicians' cognition of primary thyroid nerve sheath tumors and to provide a reference for clinical diagnosis and treatment. We present this article in accordance with the PRISMA reporting checklist.

Methods

The clinical case reports of PTS published in the PubMed database from the time of database creation to December 2022 were searched using "Thyroid nerve sheath tumor" or "Thyroid schwannoma" or "Thyroid neurilemmoma" as search terms, respectively, for statistical and summary purposes.

To decrease heterogeneity, we used uniform inclusion criteria for the retrieved case reports. Senior title surgeons set the screening criteria, and junior and mid-level surgeons searched the relevant literature and screened.

Inclusion criteria: (1) Basic information presentation of the patient is available. (2) with clinical manifestations and distribution of lesions. (3) surgical treatment and a specific diagnosis of thyroid schwannoma. (4) The lesion is located in the thyroid gland or is closely associated with the thyroid gland and is difficult to distinguish from a thyroid nodule.

Exclusion Criteria: (1) Although the primary lesion was located in the neck, it is not closely related to the thyroid gland. (2) Cases misdiagnosed as thyroid schwannoma. (3) More clinical information was missing.

Results

A total of 34 case reports were included by screening criteria, the results of which are presented in Table 1, Cont (1), Cont (2), Cont (3), Cont (4).

Discussion

The pathogenesis of p rimary thyroid schwannoma is unclear. It has been shown that thyroid transcription factor-1 (TTF-1) is expressed selectively in most nerve sheath tumors, especially in the routine variants. On this basis, TTF-1 protein and mRNA are exclusively expressed in nerve sheath tumors. Abnormal expression of TTF-1 in schwannomas provides novel clues to the mechanism of schwannoma pathogenesis. [7] Primary thyroid schwannomas are one of the rarest subgroups of neck schwannomas, and their origin is unknown; it is thought that they originate from sensory nerves within the thyroid gland or from autonomic innervation of the thyroid gland. [8] The nerve source was reported in four of the cases counted, three of which originated from the recurrent laryngeal nerve and one from the vagus nerve. [2, 9–11] Although females were more common in the statistical cases (23 females and 11 males), this cannot be used to determine sex preference due to the small number of cases. Primary thyroid schwannomas can occur at any age, in statistical cases at 12–87 years of age with a mean of 41 years; lesion size ranges from 0.8 to 14 cm with a mean size of 3.9 cm.

In most cases, the lesion was located in the right lobe of the thyroid, followed by the left lobe, while only one case involved the isthmus of the thyroid. [11] Some investigators have argued that neurological dissymmetry of the thyroid gland may cause multiple occurrences in the right lobe. [12] Primary thyroid schwannomas typically present as isolated, with only one case accumulating bilateral thyroid glands. [13] The majority of thyroid schwannomas patients only experience a painless, slowly expanding mass as their only presenting symptom. However, because of direct nerve invasion or compression of nearby tissues, other symptoms may occasionally occur, among which voice changes and dysphagia are common, as well as foreign body sensation in the larynx, [14, 15] dyspnea, [16, 17] cough, [13, 16] facial flushing and fatigue, [18] and numbness in the upper extremities, [19] etc. Primary thyroid schwannoma do not interfere with the thyroid function, and tests of thyroid function performed before the surgery are all within normal ranges.

The definitive pre-operative diagnosis of thyroid nerve sheath tumor was made in only 5 of the cases counted (14.3%), and a definitive diagnosis is often challenging and requires multiple diagnostic modalities.

The preferred test is ultrasonography (US); the best common ultrasound presentation of a thyroid schwannoma is a well-defined, regular, hypoechoic, homogeneous solid nodule; [20–22] sometimes it can also show a heterogeneous, predominantly cystic nodule. [23, 24] It can also be a nodule without pressure, with a flat surface that moves with swallowing, no signs of posterior sternal extension, and no enlarged lymph nodes palpable on the neck or clavicle. [23] Irregular nodule borders have also been described in some cases, [9] no calcification. [10] They also present as macrocalcifications or microcalcifications, which can easily be suspected as malignant tumors. [25] Calcifications in schwannomas are extremely rare, which may make the differential diagnosis difficult. Thyroid schwannoma with thickened walls and abundant internal and external peripheral blood vessels may exhibit varying degrees of echogenicity on ultrasound depending on the composition of Antoni cells and cystic lesions, but often appear hypoechoic similar to or lower than muscle tissue. [14, 22] One third of thyroid schwannomas have been found to be "target sign" (hyperechoic center and hypoechoic periphery) on ultrasound

Table 1 Clinical information on case reports related to thyroid schwannomas

Reference	Sex/Age	Size(cm)/Location	Presentation	thyroid function	Preoperative FNAC Result	Indication of surgery or Preoperative diagnosis	Surgery	Intraoperative frozen section	Histological examination	IHC
Ledgard C, et al., 2022 [48]	F/33	5.3/Left	Neck Pain and Dysphagia	Normal	non-diagnostic (acellular)	Symptomatic thyroid nodules	Nodule Removal	-	Antoni A and Antoni B	S-100 protein(+); Vimentin(+); Ki67 low proliferation
Gambardella C, et al., 2022 [35]	M/70	4.8/Right	Hoarseness and Neck discomfort	Normal	Three-dimensional solid fusion cell population	Suspicious malignancy	Right hemithyroidectomy	-	Antoni A and Antoni B	S-100 protein(+); Ki67 low proliferation
Zhao H N, et al., 2021 [19]	F/18	3.3/Left	Numbness in the left upper limb	Normal	Benign Schwannoma	Thyroid schwannoma	Left hemithyroidectomy	-	Antoni A and Antoni B	-
Alzubedi A A, et al., 2020 [16]	F/23	3.2/Left	Neck swelling; Coughing; Difficulty breathing	Normal	Lymphocyte	Invasion of adjacent tracheal wall	Left hemithyroidectomy	-	Antoni A and Antoni B	S-100 protein(+); Ki67 low proliferation; CD34(-)
Kang J Y, et al., 2020 [25]	F/33	3.0/Left	No symptoms	Normal	non-diagnostic (acellular)	Suspicious malignancy	Left hemithyroidectomy	Benign spindle cell tumor	Antoni A and Antoni B	S-100 protein(+)
Abbarah S, et al., 2020 [23]	F/33	6.0/Left	Hoarse voice and Dysphagia	Normal	Heterozygosity of uncertain meaning	-	Nodule Removal	-	Antoni A and Antoni B	S-100 protein(+)

Table 1 Cont (1)

Reference	Sex/ Age	Size(cm)/Location	Presentation	thyroid function	Preoperative FNAC Result	Indication of surgery or Preoperative diagnosis	Surgery	Intraoperative frozen section	Histological examination	IHC
Xu X Q, et al., 2018 [9]	M/61	1.0/Left	Hoarse voice	Normal	-	Suspicious malignancy	Total thyroidectomy	Papillary thyroid carcinoma	Not classified	S-100 protein(+)
Oka K, et al., 2017 [32]	M/87	-/Left	No symptoms	-	Schwannoma	Thyroid schwannoma	Nodule Removal	-	-	-
Nagavalli S, et al., 2017 [10]	F/60	4.0/Left	Dysphagia	Normal	Spindle cells with a lymphocytic background	Thyroid schwannoma	Left hemithyroidectomy	-	Antoni A	S-100 protein(+); Ki67 low proliferation
Lee Y S, et al., 2016 [49]	F/14	3.0/Right	No symptoms	-	Spindle cell composition	Suspicious malignancy	Total thyroidectomy	Benign mesenchymal tumor	Antoni A and Antoni B	S-100 protein(+);FGFR1(+)
Vazquez-Benitez G, et al., 2016 [24]	F/27	1.8/Left	No symptoms	Normal	Spindle cell	Thyroglossal duct cyst	Left hemithyroidectomy	-	Antoni A and Antoni B	S-100 protein(+); Vimentin(+); CD34(+)
Chen G, et al., 2016 [20]	M/51	2.5/Left	No symptoms	Normal	-	-	Total thyroidectomy	-	Antoni A and Antoni B	S-100 protein(+); Vimentin(+); CD34(+)

images. [19] Therefore, the "target sign" may be a unique ultrasound feature of thyroid schwannomas that can differentiate them from other common thyroid nodules. The application of multi-modality ultrasound imaging strategies to enhance the diagnosis of thyroid schwannomas has also been reported: [19] when a lesion is detected by conventional ultrasound, a different imaging modality, such as ultrasonic elastography (UE), will be applied; if the two methods are inconsistent, a contrastenhanced ultrasound (CEUS)-guided biopsy will be done, especially for bigger nodules.

Computed tomography (CT) scans of thyroid schwannomas usually show a well-defined soft-tissue dense mass that is less dense than the muscle, with increased density in the area surrounding the tumor owing to neovascularization. [18] CT performance of the mass as heterogeneous may indicate malignancy, [26] but benign schwannomas are sometimes reported as heterogeneous on CT examination. [18] On contrast-enhanced CT (CECT), Antoni A-dominant schwannomas tend to show solid, highly enhanced, heterogeneous, and hypointense lesions; Antoni B-dominant schwannomas tend to show pseudocystic, with no significant contrast enhancement. Sujita et al. interpreted that areas with better CT enhancement corresponded to the hypercellular Antoni A region, while areas with poorer enhancement corresponded to the Antoni B region. [18] Magnetic resonance imaging (MRI) is better than CT because of its greater spatial definition and the absence of exposure to ionizing radiation, however, CT is optimal for the assessment of calcification.

MRI had 100% specificity and 59% sensitivity for the target sign(a hypointense central area with a hyperintense peripheral area on T2-weighted images). [27] MRI shows well-defined solid masses, and these lesions show low to equal intensity on T1-weighted images and high intensity on T2-weighted images, depending on the size of the cells. [28] When lesions become small, they are usually homogeneous, and as lesion size increases, they become heterogeneous. In such cases, imaging features of MRI are necessary to prompt further cytological examinations to enhance the preoperative diagnosis. [10] T2-weighted MRI reveals slightly lower signal intensity in the central part of the tumor and higher signal intensity in the peripheral part of the tumor. Dumbbell shape and features called "Target Markers" on T2-weighted MRI are typical features of nerve sheath tumors. [29] On T2WI, the hypointense central region of the schwannomas corresponds to Antoni A, and the hyperintense peripheral region corresponds to Antoni B. Compared to CT, MRI can provide a more detailed characterization of the internal features, such as the cellular structure of the tumor. [29]

Another valuable imaging test is technetium TC-99 M. Previous cases with TC-99 M thyroid scans have often shown cold nodules. [11, 30, 31] Therefore, in the evaluation of cold thyroid nodules, neurogenic tumors should be included.

Preoperative examination by Fine Needle Aspiration Cytology (FNAC) clearly diagnosed schwannomas in only 2 cases, [19, 32] and these 2 cases were performed by ultrasound-guided FNAC. The majority of the remaining cases were reported as spindle-shaped cells, and some cases were under-sampled, and ultrasound-guided FNAC could improve the sampling rate. The relative sensitivity of FNAC in diagnosing schwannomas is low, ranging from 0 to 40%, and the rate of unsatisfactory specimens is 36–50%. [33, 34] Schwannomas are critical in the differential diagnosis of thyroid lumps and should be considered when FNAC shows spindle-shaped cells. For the diagnosis of thyroid schwannomas in cases lacking typical morphological features, lots of spindle-shaped cells can enter the differential diagnosis. Microscopically, spindle-shaped Schwann cells (Antoni A) and Verocay vesicles are visible. [11, 35] This restriction of FNA is owing to the histological features of schwannomas, like its dense mesenchymal component, hypocellular Antoni B area and cystic degeneration. [36]

In recent years, core needle biopsy (CNB) has been offered as a supplementary approach to FNA. CNB has high diagnostic accuracy for the histological and immunohistochemical features of numerous head and neck tumors, particularly nerve sheath tumors, which are less aggressive. [37, 38] One of these cases was definitively diagnosed as schwannomas by CNB. [39] CNB appears to be a safe and least invasive way to diagnose uncertain neck masses and avoid needless diagnostic surgery. [39] CNB is recommended in international guidelines as a diagnostic strategy for neck masses. [40]CNB has higher sensitivity, specificity, pretest value and accuracy than FNA in identifying malignant tumors, but is still poorer than open surgical biopsy.

Surgeons who decide to perform thyroid surgery should always request a frozen section prior to the procedure. On frozen sections, schwannomas are assumed to be spindle cell tumors of the thyroid gland. [25, 41] Intraoperative frozen section biopsies were performed in 9 of the statistical cases; unfortunately, none of them had a definitive diagnosis of schwannomas, but they did provide important information, such as spindle cell lesions or consideration of benign lesions. Although the diagnosis was not definitive, it provided help for the surgical approach. Definitive diagnosis ultimately relies on routine postoperative pathology and immunohistochemical staining. Gross view of schwannomas: smooth surface, intact envelope, well-defined homogeneous pale white nodules, no obvious heterogeneity, no mitotic activity, no

Table 1 Cont (2)

Reference	Sex/Age	Size(cm)/Location	Presentation	thyroid function	Preoperative FNAC Result	Indication of surgery or Preoperative diagnosis	Surgery	Intraoperative frozen section	Histological examination	IHC
Nasrollah N, et al., 2015 [39]	M/58	2.0/Right	No symptoms	Normal	Benign thyroid nodules;	Thyroid schwannoma	No surgery, follow up	-	-	S-100 protein(+)
De Simone B, et al., 2014 [13]	F/50	4.0/Left; 0.8/Right	Cough, difficulty in pronunciation and Dysphagia	Normal	non-diagnostic (acellular)	Suspicious malignancy	Total thyroidectomy	-	-	S-100 protein(+)
Dhar H, et al., 2014 [6]	M/47	6.0/Right	Neck swelling	Normal	Benign lesions	-	Right hemithyroidectomy	-	Antoni A and Antoni B	-
Pillai S, et al., 2013 [2]	F/30	7.2/Left	Hoarse voice	Normal	non-diagnostic (acellular)	Retrosternal goiter	Total thyroidectomy	-	Not classified	S-100 protein(+);Vimentin(+)
Graceffa G, et al., 2013 [11]	M/47	2.5/Isthmus	Dysphagia;Painful swallowing and hoarse voice	Normal	Nodular goiter	Nodular goiter	Total thyroidectomy	-	Antoni A	S-100 protein(+)
Jong Y N, et al., 2012 [50]	F/42	-/Left	No symptoms	-	non-diagnostic (acellular)	-	Left hemithyroidectomy	Nuclear fence with Verocay vesicles	-	-
Gamal W L, et al., 2011 [41]	M/70	5.4/Left	Hoarse voice;dysphagia	-	Follicular cell deficiency	-	Left hemithyroidectomy	Spindle cell tumors	Antoni A and Antoni B	S-100 protein(+);Vimentin(+)
Mangal N, et al., 2010 [51]	F/25	2.0/Right	No symptoms	Normal	-	Nodular goiter	Right hemithyroidectomy	-	Antoni A and Antoni B	-

Table 1 Cont (3)

Reference	Sex/ Age	Size(cm)/Location	Presentation	thyroid function	Pre-operative FNAC Result	Indication of surgery or Preoperative diagnosis	Surgery	Intraoperative frozen section	Histological examination	IHC
Subramaniam V, et al., 2010 [43]	F/30	3.5/Right	No symptoms	Normal	Colloid goiter	-	Right hemithyroidectomy	-	Antoni A and Antoni B	-
Uri O, et al., 2009 [30]	F/57	-/Right	No symptoms	Normal	Follicular cells and intranuclear cytoplasmic inclusion outside the nucleus	Suspicious malignancy	Total thyroidectomy	Malignant tumor of thyroid	-	S-100 protein(+);CD34(-)
De Paoli F, et al., 2005 [14]	F/64	3.2/Right	Foreign body sensation in the throat	Normal	non-diagnostic (acellular)	Suspicious malignancy	Total thyroidectomy	-	Antoni A and Antoni B	S-100 protein(+)
Baglaj M, et al., 2004 [52]	F/12	2.5/Left	No symptoms	Normal	Spindle-shaped cells	Thyroid spindle cell tumor	Left hemithyroidectomy	-	Antoni A and Antoni B	S-100 protein(+)
Rohaizak M, et al., 2002 [53]	F/24	3.0/Right	No symptoms	-	non-diagnostic (acellular)	-	Nodule Removal	-	Antoni A	-
Badawi R A, et al., 2002 [54]	F/23	4.0/Left	No symptoms	Normal	non-diagnostic (acellular)	-	Left hemithyroidectomy	-	Not classified	-

necrosis. [2, 16, 24] Histologically, there are five types of nerve sheath tumors, namely, common, plexiform, cellular, epithelioid, and ancient schwannomas. [42] There are three subtypes: Antoni A, Antoni B, or a mixture of these two sub-types. [18, 43] Antoni A comprises highly cellular areas that may have ordered and densely arranged spindle-shaped Chevron cells with distinctive fenestrated nuclei. The nuclei present a fenestrated shape, which results in bundles of nucleated regions arranged by the cytoplasm, called Verocay vesicles. In opposite, Antoni B comprises less order and fewer cellular areas that may include cystic degeneration. Of the reported cases, 18 had both Antoni A and Antoni B, 6 had only Antoni A, and 1 had only Antoni B.

Positive immunohistochemical staining for S-100 protein, CD34 and wave proteins helps to confirm the diagnosis and helps to differentiate it from other mesenchymal tumors. [41] Among the cases counted,100% were positive for S-100 protein expression; five cases reported positive expression of all waveform proteins; four cases were reported for CD34, two positive and two negative; [16, 30] another case reported positive for fibroblast growth factor receptor 1 (FGFR1), which may be informative; recent cases of thyroid schwannomas reported a low Ki67 proliferation index, consistent with benign tumor characteristics.

The clinical presentation and imaging of thyroid schwannomas are similar to those of thyroid nodules. The differential diagnosis includes and non-epithelial

Table 1 Cont (4)

Reference	Sex/Age	Size(cm)/Location	Presentation	thyroid function	Preoperative FNAC Result	Indication of surgery or Preoperative diagnosis	Surgery	Intraoperative frozen section	Histological examination	IHC
Gustafson L M, et al., 2001 [31]	F/20	2.5/Right	No symptoms	Normal	inflammatory cells with hemosiderin	-	Right hemithyroidectomy	-	Antoni A and Antoni B	S-100 protein(+)
Al-Ghamdi S, et al., 2000 [17]	F/42	14.0/Right	Breathing difficulties;Hoarse voice	Normal	non-diagnostic (acellular)	Suspicious malignancy	Total thyroidectomy	-	Not classified	S-100 protein(+)
Jayaram G., 1999 [46]	M/41	4.0/Right	No symptoms	Normal	Spindle shaped cells	Thyroid schwannoma	Nodule Removal	-	Antoni A	S-100 protein(+)
Sugita R, et al., 1998 [18]	M/22	1.0/Right	Facial flushing and Easy fatigue	Normal	Inflammatory tissue	-	Right hemithyroidectomy	-	Antoni A and Antoni B	-
Mikosch P, et al., 1997 [15]	M/31	3.9/Right	A feeling of discomfort in the throat	-	Long spindle cells	Benign tumor (Schwannoma or neurofibromatosis)	Nodule Removal	-	Antoni A	-
Aoki T, et al., 1993 [12]	M/57	3.6/Right	No symptoms	Normal	-	Suspicious malignancy	Nodule Removal	Consider benign tumor	Antoni A	S-100 protein(+)
Andrion A, et al., 1988 [54]	F/33	5.0/Right	No symptoms	Normal	-	Benign tumor	Nodule Removal	Spindle cell tumors	Antoni A and Antoni B	S-100 protein(+)
DELANEY W E, et al., 1964 [5]	F/50	2.5/Right	No symptoms	Normal	-	-	Right hemithyroidectomy	Consider benign tumor	Antoni B	-

FNAC: Fine needle aspiration cytology; IHC: Immunohistochemistry; FGFR1: Fibroblast growth factor receptor 1; - : Not stated

thyroid tumor, malignant thyroid nodules and thyroid adenoma. All primary non-epithelial thyroid tumors are rare, accounting for 1.0% of all thyroid tumors. [11] The differential diagnosis of benign non-epithelial thyroid tumors includes lipomas, lymphomas, teratomas, hemangiomas, and schwannomas. Imaging, FNAC, CNB and intraoperative frozen sections help to improve the preoperative diagnosis.

In clinical practice, benign thyroid schwannomas ought to be clearly distinguished from malignant ones. The vast majority of primary thyroid schwannomas in statistic cases were benign, with only one case of malignancy. [17] Malignant schwannomas are an aggressive group of tumors that can lead to a fatal outcome with or without aggressive adjuvant therapy. [44, 45] Removal by surgery is the first option of therapy. Most cases reported in the literature have undergone thyroid lobectomy or nodal removal, and all have a good prognosis. However, because of the difficulty of preoperative diagnosis, lobectomy of the thyroid gland is necessary, which may lead to more complications. [46]

Conclusions

The preoperative diagnosis of primary thyroid schwannoma is challenging and requires multiple diagnostic modalities. The preferred test is US. CT and MRI provide some help, but are of limited value. TC-99 M scan of the thyroid often shows cold nodules. Ultrasound-guided FNAC improves the sampling rate, and cytology showing spindle or spindle cells should be considered for nerve sheath tumors. CNB as a complementary method to FNAC, especially for nerve sheath tumors, has higher diagnostic accuracy with histological and immunohistochemical features. Intraoperative frozen sections are helpful for the surgical approach, but routine postoperative pathology and immunohistochemical staining are the gold standard for a definitive diagnosis. Histology with both Antoni A and Antoni B is common, and positive immunohistochemical staining for S-100 protein, CD34 and wave protein helps to confirm the diagnosis. thyroid lobectomy is necessary due to preoperative diagnostic difficulties.

Abbreviations

PTS	Primary thyroid schwannomas
TTF-1	Thyroid transcription factor-1
UE	Ultrasonic elastography
CEUS	Contrastenhanced ultrasound
CT	Computed tomography
CECT	Contrast-enhanced CT
FNAC	Fine Needle Aspiration Cytology
CNB	Core needle biopsy
FGFR1	Fibroblast growth factor receptor 1

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Author contributions

HR and LM carried out the studies, participated in collecting data, and drafted the manuscript. HR, LM and XG participated in acquisition, analysis, or interpretation of data and draft the manuscript. All authors read and approved the final manuscript.

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Data availability

All data generated or analysed during this study are included in this published article.

Declarations

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References

1. Jessen KR, Mirsky R, Lloyd AC. Schwann cells: development and role in nerve repair. Cold Spring Harb Perspect Biol. 2015;7:a020487.
2. Pillai S, Agarwal AC, Mathew M et al. Ancient schwannoma mimicking a thyroid mass with retrosternal extension. BMJ Case Rep. 2013;2013.
3. Colreavy MP, Lacy PD, Hughes J, et al. Head and neck schwannomas–a 10 year review. J Laryngol Otol. 2000;114:119–24.
4. Thompson LD, Wenig BM, Adair CF, et al. Peripheral nerve sheath tumors of the thyroid gland: a series of four cases and a review of the literature. Endocr Pathol. 1996;7:309–18.
5. Delaney WE, Fry KE. Neurilemoma of the thyroid gland. Ann Surg. 1964;160:1014–7.
6. Dhar H, Dabholkar JP, Kandalkar BM et al. Primary thyroid schwannoma masquerading as a thyroid nodule. J Surg Case Rep. 2014;2014.
7. Wang DZ, Liu P, Yao L, et al. Aberrant expression of thyroid transcription factor-1 in schwannomas. Hum Pathol. 2018;71:84–90.
8. Cashman E, Skinner LJ, Timon C. Thyroid swelling: an unusual presentation of a cervical sympathetic chain schwannoma. Medscape J Med. 2008;10:201.
9. Xu XQ, Hong T, Zheng CJ. Schwannoma originating from the recurrent laryngeal nerve in a thyroid cancer patient: a case report and review of the literature. World J Clin Cases. 2018;6:1202–5.
10. Nagavalli S, Yehuda M, McPhaul LW, et al. A cervical Schwannoma Masquerading as a thyroid nodule. Eur Thyroid J. 2017;6:216–20.
11. Graceffa G, Cipolla C, Florena AM, et al. Primary schwannoma of the thyroid gland involving the isthmus: report of a case. Surg Today. 2013;43:106–9.
12. Aoki T, Kumeda S, Iwasa T, et al. Primary neurilemoma of the thyroid gland: report of a case. Surg Today. 1993;23:265–8.
13. De Simone B, Del Rio P, Sianesi M. Schwannoma mimicking a neoplastic thyroid nodule. Updates Surg. 2014;66:85–7.
14. De Paoli F, Giugliano G, Casadio C et al. Schwannoma of thyroid bed. A case report and considerations on interdisciplinary collaboration. Acta Otorhinolaryngol Ital. 2005;25:250-2; discussion 3–4.
15. Mikosch P, Gallowitsch HJ, Kresnik E, et al. Schwannoma of the neck simulating a thyroid nodule. Thyroid. 1997;7:449–51.
16. Alzubedi A, Alessa M, Al-zuraiqi B et al. Thyroid schwannoma presenting by intractable persistent unexplained cough: a case report. 2020;4:938–40.
17. Al-Ghamdi S, Fageeh N, Dewan M. Malignant schwannoma of the thyroid gland. Otolaryngol Head Neck Surg. 2000;122:143–4.
18. Sugita R, Nomura T, Yuda F. Primary schwannoma of the thyroid gland: CT findings. AJR Am J Roentgenol. 1998;171:528–9.
19. Zhao HN, Ma BY, Yan F, et al. Multimodal ultrasound imaging of primary thyroid schwannoma: a case report. Med (Baltim). 2021;100:e25517.

20. Chen G, Liu Z, Su C, et al. Primary peripheral nerve sheath tumors of the thyroid gland: a case report and literature review. Mol Clin Oncol. 2016;4:209–10.
21. Isobe K, Shimizu T, Akahane T, et al. Imaging of ancient schwannoma. AJR Am J Roentgenol. 2004;183:331–6.
22. Beggs I. Sonographic appearances of nerve tumors. J Clin Ultrasound. 1999;27:363–8.
23. Abbarah S, Abbarh S, AlHarthi B. Unusual thyroid nodule: a case of symptomatic thyroid Schwannoma. Cureus. 2020;12:e11425.
24. Vázquez-Benítez G, Pérez-Campos A, Masgrau NA, et al. Unexpected tumor: primary asymptomatic schwannoma in thyroid gland. Endocr Pathol. 2016;27:46–9.
25. Kang JY, Yi KS, Cha SH, et al. Schwannoma of the thyroid bed: a case report and review of the literature. Med (Baltim). 2020;99:e18814.
26. Coleman BG, Arger PH, Dalinka MK, et al. CT of sarcomatous degeneration in neurofibromatosis. AJR Am J Roentgenol. 1983;140:383–7.
27. Koga H, Matsumoto S, Manabe J, et al. Definition of the target sign and its use for the diagnosis of schwannomas. Clin Orthop Relat Res. 2007;464:224–9.
28. Rath S, Sasmal PK, Saha K, et al. Ancient schwannoma of Ansa Cervicalis: a rare clinical entity and review of the literature. Case Rep Surg. 2015;2015:578467.
29. Mikoshi A, Edo H, Hase T, et al. Laryngeal schwannoma with extralaryngeal extension mimicking a thyroid tumour. BJR case Rep. 2022. https://doi.org/10.1259/bjrcr.20210089.
30. Uri O, Baron E, Lefel O, et al. Primary schwannoma of the thyroid gland presenting as an asymptomatic cold nodule. Am J Otolaryngol. 2009;30:427–9.
31. Gustafson LM, Liu JH, Rutter MJ, et al. Primary neurilemoma of the thyroid gland: a case report. Am J Otolaryngol. 2001;22:84–6.
32. Oka K, Iwamuro M, Otsuka F. Neck schwannoma mimicking a thyroid tumor. J Gen Fam Med. 2017;18:473–4.
33. Yu GH, Sack MJ, Baloch Z, et al. Difficulties in the fine needle aspiration (FNA) diagnosis of schwannoma. Cytopathology. 1999;10:186–94.
34. Zheng X, Guo K, Wang H, et al. Extracranial schwannoma in the carotid space: a retrospective review of 91 cases. Head Neck. 2017;39:42–7.
35. Gambardella C, Docimo L, Candela G, et al. Thyroid-Bed Schwannoma mimicking a thyroid neoplasm: a challenging diagnosis: report of a case and literature review. Med (Kaunas). 2022;58(10):1345.
36. Simo D, Selvaggi F, Cieri M, et al. Surgical approach for nodular neck lesions mimicking primitive thyroid neoplasms report of three cases. Ann Ital Chir. 2014;85:474–8.
37. Kasraeian S, Allison DC, Ahlmann ER, et al. A comparison of fine-needle aspiration, core biopsy, and surgical biopsy in the diagnosis of extremity soft tissue masses. Clin Orthop Relat Res. 2010;468:2992–3002.
38. Ahn D, Lee GJ, Sohn JH, et al. Fine-needle aspiration cytology versus core-needle biopsy for the diagnosis of extracranial head and neck schwannoma. Head Neck. 2018;40:2695–700.
39. Nasrollah N, Trimboli P, Bianchi D, et al. Neck schwannoma diagnosed by core needle biopsy: a case report. J Ultrasound. 2015;18:407–10.
40. Gharib H, Papini E, Paschke R, et al. American Association of Clinical Endocrinologists, Associazione Medici Endocrinologi, and European Thyroid Association medical guidelines for clinical practice for the diagnosis and management of thyroid nodules: executive summary of recommendations. J Endocrinol Invest. 2010;33:287–91.
41. Gamal WL, Abdel Khalek MS, Crawford BE, et al. Hoarseness due to a thyroid mass. Symptomatic thyroid schwannoma. Neth J Med. 2011;69:39–40.
42. Bayindir T, Kalcioglu MT, Kizilay A, et al. Ancient schwannoma of the parotid gland: a case report and review of the literature. J Craniomaxillofac Surg. 2006;34:38–42.
43. Subramaniam V, Tv A, Khandige S. Schwannoma of the thyroid gland- A case report. Jurnalul De Chirurgie. 2010;6:536–8.
44. Pallares J, Perez-Ruiz L, Ros S, et al. Malignant peripheral nerve sheath tumor of the thyroid: a clinicopathological and ultrastructural study of one case. Endocr Pathol. 2004;15:167–74.
45. Hruban RH, Shiu MH, Senie RT, et al. Malignant peripheral nerve sheath tumors of the buttock and lower extremity. A study of 43 cases. Cancer. 1990;66:1253–65.
46. Jayaram G. Neurilemmoma (schwannoma) of the thyroid diagnosed by fine needle aspiration cytology. Acta Cytol. 1999;43:743–4.
47. Ledgard C, Dickson S, Pochin R. Surgical excision of a schwannoma mimicking a thyroid nodule. ANZ J Surg. 2023;93:369–71.
48. Lee YS, Kim JS, Chung AM, et al. Primary neurilemmoma of the thyroid gland clinically mimicking malignant thyroid nodule. J Pathol Transl Med. 2016;50:168–71.
49. Jong YN, Lee JJ, Chan YJ, et al. Neurilemmoma of the thyroid gland. Intern Med. 2012;51:1641.
50. Mangal N, Agarwal AK, Sharma VK, et al. Neurilemmoma (schwannoma) of the thyroid gland: a rare case presentation. Indian J Pathol Microbiol. 2010;53:873–4.
51. Baglaj M, Markowska-Woyciechowska A, Sawicz-Birkowska K, et al. Primary neurilemmoma of the thyroid gland in a 12-year-old girl. J Pediatr Surg. 2004;39:1418–20.
52. Rohaizak M, Meah FA. Cervical sympathetic schwannoma simulating a thyroid nodule. Med J Malaysia. 2002;57:218–20.
53. Badawi RA, Scott-Coombes D. Ancient schwannoma masquerading as a thyroid mass. Eur J Surg Oncol. 2002;28:88–90.
54. Andrion A, Bellis D, Delsedime L, et al. Leiomyoma and neurilemoma: report of two unusual non-epithelial tumours of the thyroid gland. Virchows Arch Pathol Anat Histopathol. 1988;413:367–72.

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