Title page

Imaging features of laryngeal chondrosarcomas: a case series and systematic review

Short running title: Imaging features of laryngeal chondrosarcomas

Akira Baba[1*], Ryo Kurokawa[1], Mariko Kurokawa[1], Yoshiaki Ota[1], Remy Lobo[1], Ashok Srinivasan[1]

[1] *Division of Neuroradiology, Department of Radiology, University of Michigan*

*Corresponding Author:

Akira Baba

Division of Neuroradiology, Department of Radiology, University of Michigan, Ann Arbor, Michigan

1500 E Medical Center Dr, UH B2, Ann Arbor, MI 48109

Phone number: +1-734-219-2884

Fax number: +1-734-615-9800

E-mail: akirababa0120@gmail.com

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Abstract

Background and Purpose

To comprehensively summarize the characteristics of radiological findings of laryngeal conventional chondrosarcomas.

Methods

We included patients with pathologically proven laryngeal conventional chondrosarcomas with CT and /or MRI, including 41 cases from 31 publications recruited after a systematic review and 14 cases from our institution. Two board-certified radiologists reviewed and evaluated all the radiological images. The relationship between pathological grade and radiological findings was analyzed.

Results

The median long diameter of the lesion was 3.1 cm (range, 1.5−8.5 cm). The most common location was the cricoid (74.5%), followed by the thyroid (12.7%), cricoid and thyroid (7.3%), and arytenoid (5.5%). All lesions showed well-defined margins. Cortical defect/expansion (98.0%), internal low density (89.6%), and calcification (95.8%) with

homogeneous and scarce contrast enhancement on contrast-enhanced CT (85.3%) were frequently observed. All cases showed high signal on T2-weighted imaging, low signal on T1-weighted imaging (T1WI), and heterogeneous and mild contrast enhancement on post-contrast T1WI. No significant differences were found between the pathological grades and radiological findings.

Conclusions

In our summary of comprehensive CT and MRI findings of laryngeal conventional chondrosarcomas, we found that the knowledge of these radiological features may facilitate prompt diagnosis and appropriate management.

Introduction

Laryngeal chondrosarcomas are very rare tumors that account for approximately 0.2% of all laryngeal tumors.[1] Nevertheless, they are the third most common laryngeal tumor after squamous cell carcinomas and adenocarcinomas[1] and the most common non-epithelial mesenchymal tumor of the larynx. The most common location of origin is the cricoid cartilage, followed by the thyroid cartilage, arytenoid cartilage, and epiglottis cartilage.[2] Histopathologically, chondrosarcomas are classified into grades I to III, with grade I being the most common, and conventional subtypes account for 97.9% of laryngeal chondrosarcomas, while the rare pathological variations include clear cell, myxoid, and dedifferentiated subtypes.[2] Preoperative diagnosis is mainly made by radiological imaging and biopsy, and most cases are treated surgically.[2] Imaging findings using CT have been reported in individual case reports or case series,[3,4] and a systematic review mainly focused on the clinical concerns regarding laryngeal chondrosarcomas with a very few radiological descriptions.[2] However, no comprehensive study with a sufficient number of cases exists on the imaging findings of laryngeal chondrosarcomas. Furthermore, MRI findings of laryngeal chondrosarcoma have not been reported, despite the characteristic MRI findings in

conventional intramedullary chondrosarcoma.[5,6] Summarizing the characteristics of CT and MRI imaging findings of laryngeal chondrosarcoma has clinical significance in facilitating prompt diagnosis and appropriate management. This study aimed to comprehensively summarize the characteristics of radiological imaging findings of laryngeal conventional chondrosarcoma using a systematic review of cases from our institution and from the literature.

Methods

Study selection

MEDLINE via PubMed, Scopus, and Embase databases were screened for radiological imaging of laryngeal chondrosarcomas up to August 13, 2021. The search terms/combinations were as follows:

・(chondrosarcoma) AND (laryngeal cartilage OR laryngeal OR thyroid cartilage OR cricoid cartilage OR cricoid OR arytenoid cartilage OR arytenoid OR epiglottic cartilage OR

epiglottic OR epiglottis OR corniculate OR cuneiform) AND ((radiology) OR (imaging) OR (computed tomography) OR (magnetic resonance imaging) OR (CT) OR (MRI)).

The inclusion criteria were as follows: pathological diagnosis of primary laryngeal chondrosarcoma; with analyzable CT and/or MRI images; and case reports or case series. The exclusion criteria were as follows: clear cell or myxoid, dedifferentiated, or secondary chondrosarcomas; only descriptive findings of CT or MRI; insufficient imaging data; written in languages other than English; unavailability of full text; and other types of records, including books and conference proceedings without a peer-reviewed full-fledged publication.

We obtained our institutional review board approval for including cases. Medical charts of the included cases were searched using the term “laryngeal chondrosarcomas.” Data were acquired in compliance with all applicable Health Insurance Portability and Accountability Act regulations. This study was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement.[7]

Data analyses

Two board-certified radiologists with 9 and 13 years of experience in neuroradiology independently reviewed all the studies and CT and MR images of the eligible studies. If the two observers reached the same result, that result was used; however, when the results differed, the final result was decided by consensus.

Collected data

We collected demographic and clinical data, including patient sex, age, chief complaints, treatment method, pathological grade, presence of locoregional/remote recurrence, disease-free survival duration, disease-specific survival, and disease-specific survival duration. Regarding radiological findings, we evaluated the following parameters: size (long diameter, short diameter), location (cricoid cartilage, thyroid cartilage, arytenoid cartilage), laterality, tumor margin (well- or ill-defined), the presence of cortical defect/expansion, CT value of the main component compared with the adjacent muscle, the presence of matrix

calcification, calcification morphology (granular, linear, coarse, and whole), enhancement on contrast-enhanced CT (CECT), signal intensity on T2-weighted imaging (T2WI) and signal intensity on T1-weighted imaging (T1WI) were compared using the spinal nerve of same plane axis, enhancement on MRI, apparent diffusion coefficient (ADC) value, presence of abnormal neck lymph nodes on imaging, and remote lesions if any (considered positive if observed in any imaging modality or mentioned in manuscript).

Quality assessment

We reviewed the studies using the tool to evaluate the methodological quality of case reports and case series proposed by Murad et al.,[8] which is based on four domains (selection, ascertainment, causality, and reporting) and eight signaling questions.

Statistical analysis

The pathological grades were divided into two groups: low-grade (grade I) and high-grade groups. Between these two groups, age and lesion size were compared using Mann–Whitney

U-tests, and sex, tumor location, the presence of cortical bone defect/expansion, CT value of the main component, presence of matrix calcification, and calcification morphology (coarse/whole or others) were compared using Fisher's exact test. Statistical significance was set at $p < 0.05$. All statistical analyses were performed using the R version 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Study selection

A database search using PubMed, SCOPUS, and Embase identified. After study selection according to the PRISMA 2020 guidelines,[7] 31 studies with 41 patients with laryngeal conventional chondrosarcomas met the criteria for the systematic review (Figure 1).[3,4,9–37] The year of publication of the studies included in this review ranged from 1988 to 2021. With an additional 14 cases in our institution (Table 1), the final study cohort included 55 cases.

Risk of bias

As we extracted data from case-based studies, the selection method was hardly mentioned, which might have introduced a selection bias. Pathological verification was based on surgical specimens in most cases (40/41, 97.6%), while the one case was based on biopsy specimens. The number of cases varied among the following parameters: sex (35/41, 85.4%), chief complaint (36/41, 87.8%), pathological grading (51/41, 90.2%), locoregional and distant metastasis/duration, and disease-specific survival/duration (29/41, 70.7%), lesion size (15/41, 36.6%), laterality (40/41, 97.6%), cortical defect/expansion (36/41, 87.8%), CT value (35/41, 85.4%), calcification (37/41, 90.2%), CECT (25/41, 61.0%), signals on T2WI (7/41, 17.1%), signals on T1WI (2/41, 4.9%), enhancement on MRI (1/41, 2.4%), and neck lymph nodes and remote lesions (39/41, 95.1%). The follow-up duration in surviving patients ranged from several months to more than ten years. In most cases, not all sequences on CT and MRI that we investigated were performed, or the results were mentioned.

Demographic and clinical data

Patient demographics and clinical data are summarized in Table 2. The median patient age at diagnosis was 63 years (range, 34–87 years), and the number of males (n = 39) was higher than that of females (n = 10). Hoarseness was the most common symptom (19/74, 25.7%), followed by dyspnea (16/74, 21.6%), dysphonia (8/74, 10.8%), and dysphagia (7/74, 9.5%). The treatment method was mostly surgical (52/55, 94.5%). The most common pathological grade was grade I (41/51, 80.4%), followed by grade II (5/51, 9.8%), grades I–II (3/51, 5.9%), and grade III (2/51, 3.9%). No locoregional or remote recurrence or disease-specific deaths were observed in any of the confirmed cases. The median disease-free survival and disease-specific survival durations were 730 days (range, 111–5575).

Radiological findings

CT and MRI were performed on 51 and 13 patients, respectively. Contrast media was used in 34 patients for CT and in 6 patients for MRI. The radiological findings are summarized in Table 3. The median long diameter of the lesion was 3.1 cm (range, 1.5−8.5). The most

common lesion location was the cricoid (41/55, 74.5%), followed by the thyroid (7/55, 12.7%), cricoid and thyroid (4/55, 12.7%), and arytenoid (3/55, 5.5%). No laterality of the lesion location was observed. All lesions showed well-defined margins. Cortical defect/expansion was observed in almost all lesions (49/50, 98%). Internal CT values revealed low density in most lesions (43/48, 89.6%). Almost all lesions had calcification (46/50, 95.8%), and the most common type was coarse calcification (17/46, 37.0%), followed by granular (10/46, 21.7%), coarse and granular (8/46, 17.4%), and granular and linear (5/46, 10.9%). The CECT revealed homogenous and minimal contrast effects in most cases (29/34, 85.3%). High signal on T2WI, low signal on T1WI, and heterogeneous and mild contrast enhancement on post-contrast T1WI were observed in all cases. ADC values were confirmed in only two cases, 1.64 and 1.76 ($10^{-3}mm^2/s$). No neck lymph nodes or remote lesions were identified in any of the cases. Three representative cases from our institution are presented in Figures 2–4.

Pathoradiological correlation

Between the low-grade group (41 cases) and the other group (10 cases), no significant differences were observed in age ($p = 0.117$), lesion size ($p = 1$), sex ($p = 0.661$), tumor location ($p = 0.113$), laterality ($p = 0.713$), presence of cortical bone defect/expansion ($p = 1$), CT value ($p = 0.713$), the presence of cortical bone defect/expansion ($p = 1$), CT value of the main component ($p = 0.571$), presence of matrix calcification ($p = 0.06$), and calcification morphology ($p = 0.07$).

Discussion

In this review of 55 laryngeal conventional chondrosarcoma cases, the tumors were frequently detected in the cricoid cartilage and were observed as a well-defined mass with a defect/expansile cortex. On CT imaging, the main internal component of the lesion tended to have low density, with various forms of calcification and minimal contrast enhancement. MRI showed high signal on T2WI, low signal on T1WI, with heterogeneous and mild enhancement. No significant correlation was identified between pathologic grade and imaging findings. To the best of our knowledge, this is the largest systematic review of radiological features of laryngeal chondrosarcomas.

A chondrosarcoma is a malignant tumor involving cells that produce a cartilage matrix. Chondrosarcoma of the larynx is a rare laryngeal tumor, although it is the most common non-epithelial mesenchymal laryngeal tumor. [1] Its etiology is unknown; however, it may be caused by disorganized ossification of the cartilage.[38] It is more common among Caucasians.[39] Chin et al, reported that the mean age was 62.5 years (15−93 years) with a male to female ratio of 3:1; the most common symptom was hoarseness, followed by dyspnea and neck masses; and surgical treatment is the most common treatment method (99%), while radiotherapy and chemotherapy are rare (1%).[2] All these results are very similar to those of our study. The frequency of pathological grade of chondrosarcomas is reported to be 67.8% for grade I (highly differentiated), 23.5% for grade II (moderately differentiated), and 3.8% for grade III (poorly differentiated) (3.8%).[2] Here, the frequency of grade 1 was similar in that it was the most common grade. A chondrosarcoma rarely metastasizes and has a significantly better prognosis than other laryngeal malignancies, with reported 1-, 5-, and 10-year disease-specific survival rates of 96.5%, 88.6%, and 84.8%, respectively.[1] The disease-free and disease-specific survival rates of the patients in this study were 100% for the

period 111–5575 days, and the favorable prognosis of chondrosarcomas was in line with that of previous reports.

Imaging studies of primary laryngeal chondrosarcomas have been limited and there have been no studies regarding the frequency of each finding or variation. This study reported the largest number of cases with imaging finding. All tumors showed well-defined margins. Although most cases of laryngeal chondrosarcomas in this study were of low grade (grade I), the margins of non-grade I chondrosarcomas (I–II, II, III) were also well-defined, which might be an underrecognized feature of laryngeal chondrosarcomas. Although the imaging findings of intramedullary lesions have been reported,[5,40,41] the difference in findings with laryngeal cases have not been elucidated. In intramedullary conventional chondrosarcomas, non-calcified components showed a lower density on CT, reflecting the higher water content of the hyaline cartilage,[5] which were corresponding with the most cases in this study. In intramedullary conventional chondrosarcomas, matrix mineralization is observed as granular and linear calcification,[5] and the frequency of calcification on CT has been reported to be 94%,[42] similar to the frequency of lesion calcification in this study (95.8%). Additionally, the

shape of calcification in this study showed mostly coarse and granular calcification, similar to that of previous reports of laryngeal chondrosarcomas on CT.[3,4] In intramedullary conventional chondrosarcomas, cortical thinning, endosteal scalloping, and destruction are characteristic findings compared to chondromas,[40,41] and the cortical defect/expansion investigated in this study corresponds to these findings and was observed in almost all cases.

Regarding MRI findings, intramedullary lesions have been reported,[5,6] however, the difference from laryngeal lesions has not been clarified. It has been reported that an MRI of a conventional intramedullary chondrosarcoma shows high signal on T2-weighted images and low signal on T1-weighted images,[5,43] and the present study confirmed that chondrosarcomas of the larynx show a similar signals. This is also considered to reflect the high water content of the vitreous cartilage[5] as well as the internal low-density findings on CT, and this signal intensity is considered a characteristic finding in laryngeal chondrosarcomas. The ADC values of skull base chondrosarcomas are reported to be higher than that of chordomas, with a median value of $2.051 \times 10^{-3} mm^2/s$.[6] The ADC values of laryngeal chondrosarcomas in the present study were measured in only two cases and were relatively high at 1.64 and 1.76 ×

$10^{-3}mm^2/s$. The high ADC values may be characteristic imaging findings in laryngeal chondrosarcomas same as in skull base chondrosarcomas.

Pathologic grade I lesions are mainly composed of chondroid matrix, grade II lesions have less chondroid matrix and correspondingly higher cellularity, and grade III lesions have higher cellularity and higher nuclear pleomorphism than grade II lesions.[5] Although these pathological features seemed to affect imaging findings such as calcification on CT and size, no significant correlation was observed between pathological grade and imaging findings in this study. The definite cause is unknown, but it has been hypothesized that this may be due to the small number of cases or the fact that the pathological grade does not have a significant morphological difference to be reflected in the imaging findings.

The main differential diagnosis for a low-grade chondrosarcoma, which accounted for most of the cases in this study, is a chondroma.[5,44] Imaging findings of chondromas of the laryngeal cartilage have not been summarized to date. Difficulty has been reported in

distinguishing chondromas from conventional intramedullary chondrosarcomas of the long bones.[41] Case reports on laryngeal chondromas stated that it can be seen as a non-specific nodule,[45] and CT imaging findings are similar to those of laryngeal chondrosarcomas in this study, such as a lesion with low density, well-defined margins, coarse and granular internal calcification, and cortical bone defect/expansion.[46,47] Therefore, differentiating between the two on imaging may be difficult. There have been no comprehensive reports on the imaging findings of the variants of laryngeal chondrosarcomas, such as clear cell chondrosarcomas, myxoid chondrosarcomas, and dedifferentiated chondrosarcomas. Case reports have shown that these variants, as well as chondrosarcomas and chondromas, have low density, well-defined margins, internal calcification (or no calcification), and cortical bone defect/expansion on CT imaging, suggesting that they may be difficult to differentiate on imaging.[48,49,50]

This study has several limitations. There was no significant correlation between histopathologic grade and imaging findings, although this may have been due to the small number of non-grade I cases. Large-scale studies with more subjects diagnosed with

non-grade I chondrosarcomas are warranted for future studies. Clear cell, myxoid, and dedifferentiated chondrosarcomas were not included in the study. The conventional subtype included in this study is considered more significant in clinical practice, as the other subtypes are very rare. The image quality of each case was heterogeneous due to the wide range of years in publication and improvements in imaging modalities in more recent years. This might have introduced bias in investigation of imaging findings. Studies with uniform protocol and modalities is warranted. Since most cases included in this study survived and had a very good prognosis with no evidence of recurrence, it was not possible to examine whether imaging findings correlated with prognosis. The number of MRI cases was limited, both at our institution and in the literature, and imaging protocol was lacking. Although ADC values were collected in only two cases in this study, future studies with more cases are recommended for investigating ADC values in laryngeal chondrosarcomas.

In conclusion, we summarized comprehensive CT and MRI findings of laryngeal conventional chondrosarcomas. The knowledge of these features may facilitate prompt diagnosis and appropriate management.

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The authors declare that they have no competing interests.

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Tables

Table 1. Demographic, clinical, and radiological data of the 14 patients with laryngeal cartilage chondrosarcoma in our institution

Patients		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Demographic & clinical data	Sex	F	M	M	M	F	M	M	M	F	M	M	M	M	F
	Age (years)	57	78	61	46	56	56	67	81	56	63	48	36	67	58
	Chief complaints	Unknown	Dysphonia	Dysphagia	Unknown	Unknown	Unknown	Dysphagia Odynophagia	Dysphonia	Unknown	Unknown	Cervicalgia	Unknown	Dyspnea Stridor Cough	Dyspnea Wheezing
	Treatment method	Surger	Surgery	Surgery	Surger	Surger	Surger	Surgery	Biopsy an	Surger	Surger	Surgery	Biopsy an	Surger	Surger

		y			y	y	y		d fol lo w-up	y	y		d fol lo w-up	y	y
	Pathological Grade	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Locoregional and hematogenous recurrence	N o	No	No	N o	N o	N o	No		N o	N o	No		N o	No
	Disease free survival duration (day)	36 42	61 0	12 82	55 75	39 52	34 4	403		36 01	14 60	22 48		11 1	13 21
	Patient status (disease-specific survival)	Su rvi ve	Su rvi ve	Su rvi ve	Su rvi ve	Su rvi ve	Su rvi ve	Sur viv e	Su rvi ve	Su rvi ve	Su rvi ve	Sur viv e	Su rvi ve	Su rv iv e	Su rvi ve
	Disease-specific survival duration (day)	36 42	61 0	12 82	55 75	39 52	34 4	403	24 5	36 01	14 60	14 60	26 8	11 1	13 21
Radiolo	CT	Ye s	Ye s	Ye s	Ye s	Ye s	N o	Yes	Ye s	Ye s	Ye s	Ye s	Ye s	Y es	Ye s

gical data	MRI	No	Yes	Yes	No	No	Yes	No	No	No	Yes	No	No	Yes	No
	Size (cm: long diameter x short diameter)	2.2 x 2.2	3.4 x 2.5	3.1 x 2.2	5.3 x 1.8	1.7 x 1.6	4.7 x 3.4	4.9 x 4	3.1 x 3.1	1.5 x 1.4	4.9 x 4.1	8.5 x 3.3	2.9 x 2.5	4 x 3.8	2.6 x 2.3
	Location	Cricoid	Cricoid	Cricoid	Cricoid	Cricoid	Cricoid	Thyroid Cricoid	Cricoid	Cricoid	Cricoid	Arytenoid	Cricoid	Cricoid Thyroid	Cricoid
	Laterality	Left	Right	Right	Middle	Right	Right	Right	Middle	Right	Right	Left	Left	Left	Left
	Tumor margin	Well	Well	Well	Well	Well	Well	Well	Well	Well	Well	Well	Well	Well	Well
	Cortical defect/expansion	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	CT value of main component	Low	Low	Low	Low	Low		Low	Low	Low	Low	Low	Low	Lo	Low

compared to adjacent muscle														w	
Matrix calcification	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Calcification morphology (Granular, linear, coarse)	Coarse	Coarse Granular	Coarse	Granular	Granular		Granular	Coarse Liner	Coarse	Coarse	Coarse Granular	Coarse Granular	Coarse Granular		
Enhancement on CT	Minimal	Minimal	Minimal	Minimal	Minimal		Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
Signals on T2-weighed imaging		High	High			High				High				High	
Signals on T1-weighted imaging		Low	Low			Low				Low				Low	
Enhancement on MRI		Scarc	Scarc			Mild				Mild				Mild	

		e	e												
ADC value (10^{-3} mm^2/s)		1.76												1.64	
Abnormal neck lymph node lesion on imaging	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Remote lesion (radiological and clinical information)	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No

Note, the data were not available in the blank boxes.

F, female; M, male; ADC, apparent diffusion coefficient

Table 2. Demographic and clinical information of the 55 patients with laryngeal chondrosarcoma

Demographic	
Sex	Male = 39, Female = 10, Not described = 6
Median age (years [range]) (n = 55)	63 (34− 87)
Clinical	
Chief complaints (n = 74)	
Hoarseness	19 (25.7%)
Dyspnea	16 (21.6%)
Dysphonia	8 (10.8%)
Dysphagia	7 (9.5%)
Odynophagia	4 (5.4%)
Shortness of breath	3 (4.1%)
Neck mass	2 (2.7%)
Stridor	2 (2.7%)
Other symptoms	6 (8.1%)
Unknown	7 (9.5%)

Treatment method (n = 55)	
Surgery	52 (94.5%)
Radiotherapy	1 (1.8%)
Follow-up	2 (3.6%)
Pathological Grade (n = 51)	
I	41 (80.4%)
I to II	3 (5.9%)
II	5 (9.8%)
III	2 (3.9%)
Locoregional and hematogenous recurrence (n = 33)	0/33 (0%)
Disease free survival duration (median day [range]) (n = 33)	730 (111−5575)
Patient status (disease-specific survival) (n = 45)	0/45 (0%)
Disease-specific survival duration (median day [range]) (n = 45)	730 (111−5575)

n, number

Table 3. Radiological characteristics of the 55 patients with laryngeal chondrosarcoma

Parameters	
Size (long diameter: cm [range]) (n = 29)	3.1 (1.5 − 8.5)
Location (n = 55)	
Cricoid	41 (74.5%)
Cricoid and thyroid	4 (7.3%)
Thyroid	7 (12.7%)
Arytenoid	3 (5.5%)
Laterality (n = 54)	
Right	24 (44.4%)
Left	22 (40.7%)
Middle	8 (14.8%)
Tumor margin (n = 55)	
Well	55 (100%)
Cortical defect/expansion (n = 50)	
Yes	49 (98%)

No	1 (2%)
CT value of main component compared to adjacent muscle (n = 48)	
Low	43 (89.6%)
High	5 (10.4%)
Iso	0 (0%)
Matrix calcification (n = 50)	
Yes	46 (92.0%)
No	4 (8%)
Calcification morphology (n = 46)	
Coarse	17 (37.0%)
Coarse and granular	8 (17.4%)
Coarse and liner	3 (6.5%)
Granular	10 (21.7%)
Granular and liner	5 (10.9%)
Linear	1 (2.2%)
Whole	2 (4.3%)
Enhancement on CT (n = 34)	
Homogenous, minimal	29 (85.3%)

Heterogenous, slight	5 (14.7%)
Signals on T2WI (n = 12)	
High	12 (100%)
Signals on T1WI (n = 7)	
Low	7 (100%)
Enhancement on MRI (n = 6)	
Heterogenous, mild	6 (100%)
ADC value (10^{-3} mm^2/s) (n = 2)	1.64 and 1.76
Neck lymph node lesion on imaging (n = 53)	53 (100%)
Remote lesion (radiological and clinical information)	53 (100%)

n, number; T2WI, T2-weighted imaging; T1WI, T1-weighted imaging, ADC, apparent diffusion coefficient

Figure legends

Figure 1. Flow diagram of study selection based on the Preferred Reporting Items for Systematic Reviews and Meta-analyses 2020 flowchart for the article selection process. After applying the selection criteria, we identified 33 articles eligible for this systematic review

n, number

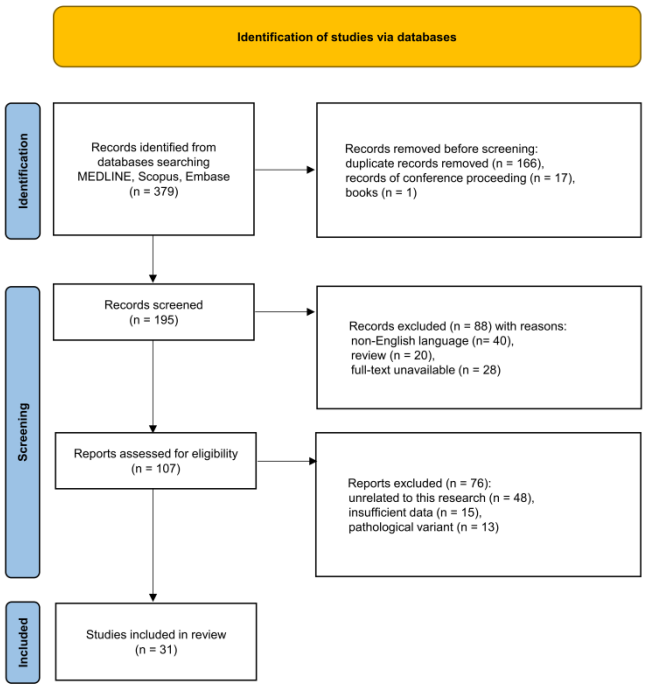

Figure 2. A laryngeal conventional chondrosarcoma in a 78-year-old male patient (case 2). Contrast-enhanced CT (a) shows a low-density mass (arrow) with a well-defined margin on the right side of the cricoid cartilage with minimal enhancement, calcification, and cortical defect/expansion. Bone window CT (b) shows coarse, granular calcification (within the circle) inside the lesion. The internal part of the lesion shows high signal (c) on T2-weighted image (arrow) and low signal (d) on T1-weighted image (arrow). Gadolinium contrast-enhanced T1-weighted image (e) shows mild and heterogeneous enhancement with peripheral predominance (arrow). The apparent diffusion coefficient (ADC) map (f) shows a high ADC value of 1.76×10^{-3} mm^2/s in the region of interest.

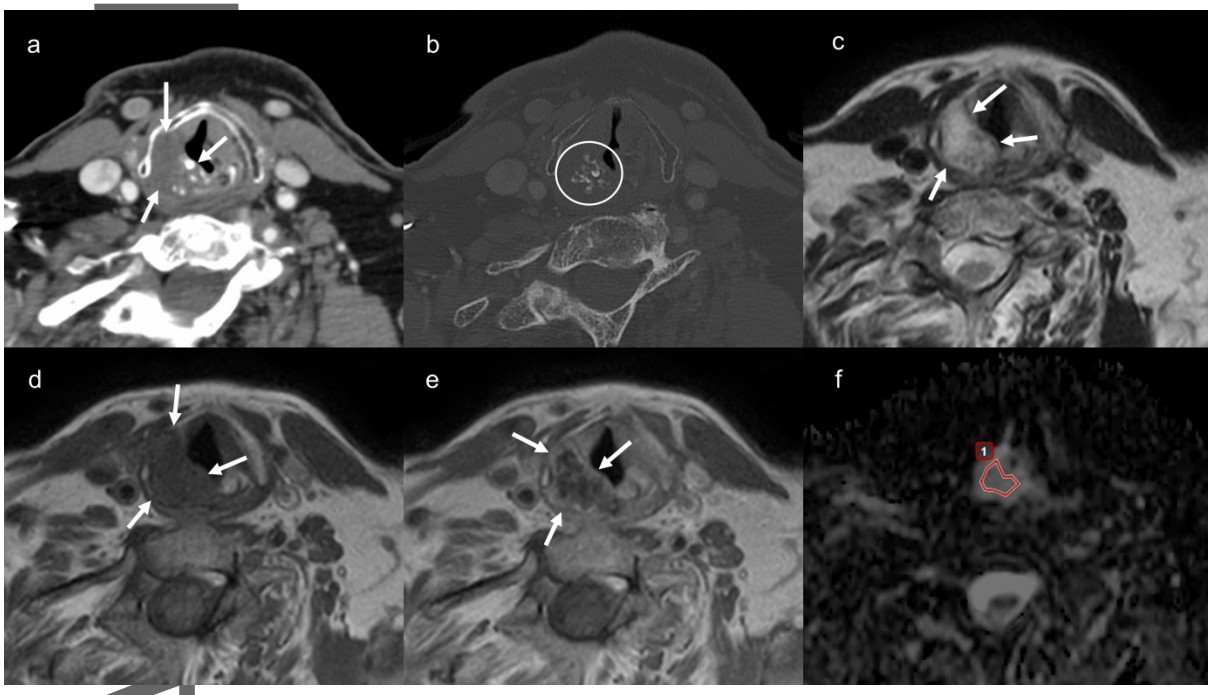

Figure 3. A laryngeal chondrosarcoma in a 36-year-old male patient (case 12).

Contrast-enhanced CT (a) shows a lobulated mass (arrow) with a well-defined margin on the left side of the cricoid cartilage with minimal enhancement, calcification, and cortical defect/expansion. Bone window CT (b) shows coarse, granular calcification (within the circle) inside the lesion

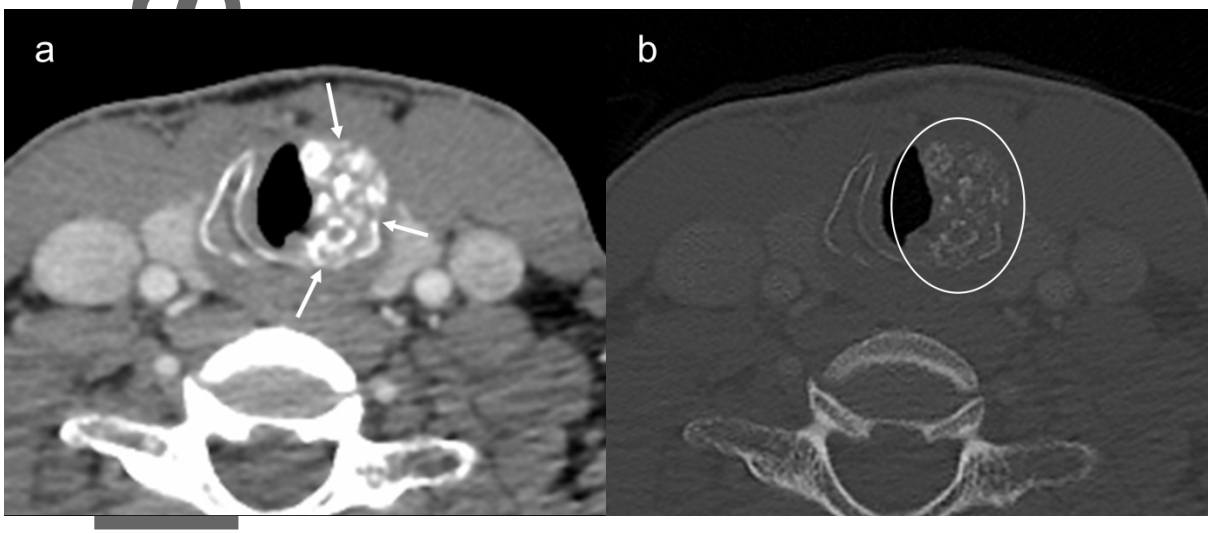

Figure 4. The laryngeal chondrosarcoma in a 58-year-old female patient (case 14).

Contrast-enhanced CT (a) shows a low-density mass (arrow) on the left side of the cricoid cartilage with minimal enhancement and cortical defect/expansion. Bone window CT (b) showed no calcification inside the lesion

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