Spaces of the Neck

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1.1 Introduction

This chapter describes an anatomic approach to pathology of the neck. A solid understanding of the anatomic boundaries of the spaces of the neck allows one to elucidate a focused differential diagnosis and evaluate for specific invasion or extension; these insights help the surgeon determine optimal operative management. This chapter will focus on the parapharyngeal, masticator, carotid, and posterior spaces. The parotid, submandibular/sublingual, and pharyngeal mucosal spaces are discussed in detail in other chapters.

Accurate interpretation of head and neck imaging requires an understanding of fascial layers, which cannot be precisely delineated with imaging; in practice, key anatomic landmarks define these fascial layers. The superficial cervical fascia (SCF) envelops fat, loose connective tissue, the platysma, and the external jugular veins. The deep cervical fascia (DCF) is further divided into superficial (SLDCF), middle (MLDCF), and deep (DLDCF) layers that form the boundaries of the spaces of the suprahyoid neck described in detail below.

1.2 Imaging Evaluation

Conventional radiography has largely been replaced by cross-sectional imaging in the evaluation of the soft tissues of the neck.

In the appropriate setting, ultrasound is a valuable tool in evaluation of the neck. Superficial lesions can typically be adequately imaged and described in the hands of an experienced sonographer. Ultrasound provides the added benefit of providing real-time image guidance for biopsy or drainage. However, ultrasound is inadequate in the evaluation of the deeper spaces of the neck.

CT is the mainstay of evaluation of neck lesions. Intravenous contrast is recommended, as lesions often cannot be delineated from adjacent normal tissues without

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it. Dental amalgam can sometimes present a challenge in evaluation of masses in the pharyngeal mucosal, sublingual, submandibular, and masticator spaces; this can often be overcome by angling the gantry at 15–25° (so-called butterfly cuts) and reimaging through the oral cavity.

MRI is a very useful tool for evaluating head and neck masses. When used with a dedicated neck coil, the deep and superficial structures of the neck can be clearly identified. Intravenous contrast is recommended to help characterize masses and enable accurate detection of tumor spread. When evaluating for spread of malignancy, it is vital to obtain precontrast T1-weighted images without fat suppression. The bright signal intensity of fat on this sequence provides a useful background against which the soft tissue intensity of tumor can be detected. The addition of fat suppression to post-contrast sequences facilitates better delineation of the enhancing tumor margins. The main disadvantages of neck MRI are the artifacts produced by dental hardware or amalgam and the length of time the patient may have to remain in the scanner (often 30–60 min), which frequently results in motion artifact.

1.2.1 Parapharyngeal Space

1.2.1.1 Anatomy

In clinical otolaryngology, the term "parapharyngeal space" has been used inclusively to refer to what is described above as the PPS and the carotid space. In this nomenclature scheme, the two distinct compartments were identified as the prestyloid and poststyloid compartments, respectively. For the purposes of consistency in this discussion, the terms PPS (prestyloid compartment) and carotid space (poststyloid compartment) will be used.

The parapharyngeal space (PPS) can be thought of as an inverted pyramid extending from the inferior surface of the petrous bone to the lesser horn of the hyoid bone. Its central location in the deep spaces of the suprahyoid neck results in a complex fascial anatomy (Fig. 1.1). The PPS extends medially to the aerodigestive tract; the visceral fascia is its medial border. The visceral fascia (deepest layer of MLDCF) adheres to the visceral structures of the neck, including the pharynx, larynx, esophagus, trachea, thyroid gland, and parathyroid glands. Anteriorly and laterally, the PPS abuts the masticator and parotid spaces, respectively. The SLDCF splits to envelop these spaces. As such, the anterior and lateral walls of the parapharyngeal space are leaflets of the SLDCF. The DLDCF of the carotid space and that of the lateral margin of the retropharyngeal space demarcate the posterior margin of the PPS. Some texts indicate that there is no fascial separation between the PPS and the submandibular space, allowing direct spread of infection or tumor between the two spaces.

The PPS is predominantly comprised of fat, making it readily identifiable on CT and MRI (Fig. 1.1). Also present are small branches of the mandibular division of

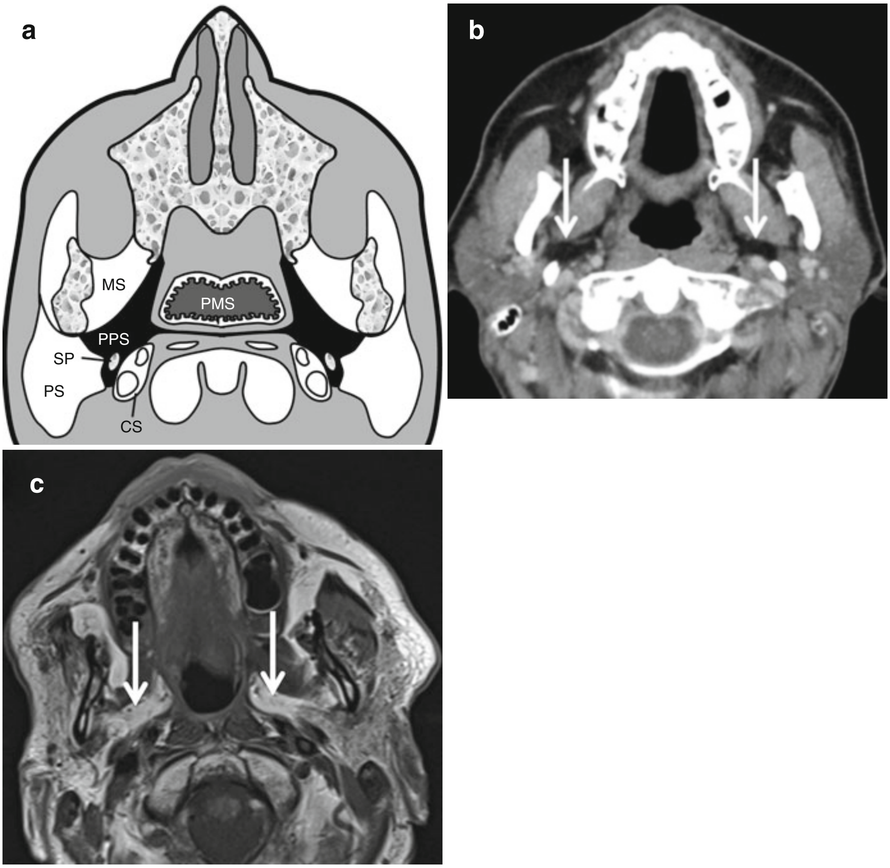


Fig. 1.1 Neck spaces. Axial graphic (**a**), CT (**b**), and T1-weighted MR (**c**) images show the normal anatomy of the parapharyngeal space (*PPS*). This space predominantly contains fat and can be easily identified (*arrows* in **b** and **c**) on both CT (hypodense on CT) and MR (bright on T1-weighted sequences) images. The central location of this space is the reason for its displacement in lesions arising from the adjacent masticator space (*MS*), parotid space (*PS*), carotid space (*CS*), and the pharyngeal mucosal space (*PMS*). The styloid process (*SP*) is along the posterior aspect of the parapharyngeal space. Note that, infrequently, lesions can arise primarily from within the parapharyngeal space and can be completely surrounded by adjacent fat

the trigeminal nerve (V3), the ascending pharyngeal artery, the internal maxillary artery, lymph nodes, and minor salivary rests (Box 1.1).

When a mass arises in an adjacent space, the fat in the parapharyngeal space can become deformed and displaced. Observation of the direction in which the mass displaces the parapharyngeal fat can help determine the origin of the mass (Fig. 1.2). Box 1.2 summarizes the expected effect of adjacent masses on the parapharyngeal space.

1.2.1.2 Pathology

Primary masses of the PPS are rare. More commonly, tumors arise from the deep lobe of the parotid gland or from an adjacent space and extend into the PPS. The most common masses involving the parapharyngeal and the adjacent spaces are listed in Box 1.1.

Of the primary PPS neoplasms, benign tumors account for 80 %. The most common is a pleomorphic adenoma (benign mixed tumor) arising from a minor salivary

Box 1.1. Spaces of the Neck: Contents and Lesions

Space	Contents	Lesions
Parapharyngeal space	Fat	Benign mixed tumors – either from ectopic rests in parapharyngeal space or from deep lobe of the parotid
	Ectopic rests of salivary glands	Lipoma
	Branches of mandibular division of trigeminal nerve	Schwannomas
	Internal maxillary artery	Cellulitis/abscess
	Ascending pharyngeal artery	
	Pharyngeal venous plexus	
[a]Masticator space	Internal maxillary artery and its branches	Odontogenic abscess
	Mandibular nerve and its branches	Sarcomas
	Ramus/body of mandible	Neurogenic tumors
	Muscles of mastication	Vascular malformations
		Perineural spread of carcinomas
		Secondary involvement from jaw, skull base, and pharyngeal mucosal space lesions
Carotid space	Internal carotid artery	Internal carotid artery aneurysm/dissection
	Internal jugular vein	Internal jugular vein thrombosis
	Cranial nerves IX–XII	Schwannomas/neurofibromas of the cranial nerves IX–XII and sympathetic chain
	Cervical sympathetic chain	Paragangliomas – carotid body tumors, glomus vagale
	Glomus bodies	Inferior extension of lesions from jugular foramen (schwannomas/neurofibromas/meningiomas/glomus jugulare)
	Jugular chain nodes	Metastatic adenopathy
[a]Parotid space	Parotid gland	Salivary gland tumors
	Intraparotid lymph nodes	Metastatic tumors
	Facial nerve and branches	Lymphomas
	Internal carotid artery	Perineural extension through facial nerve
	Retromandibular vein	Cystic lesions

Space	Contents	Lesions
[a]Pharyngeal mucosal space	Squamous epithelial mucosa	Squamous cell cancers incl. nasopharyngeal carcinomas
	Lymphoid and tonsillar tissue	Lymphomas
	Minor salivary glands	Minor salivary gland tumors
[a]Visceral space	Larynx and hypopharynx	Squamous cell cancers
	Thyroid and parathyroid	Thyroid and parathyroid tumors
	Esophagus	Vascular malformations
		Thyroglossal and branchial cysts
		Benign mesenchymal and neurogenic tumors
		Dermoids/epidermoids
Retropharyngeal space	Fat	Metastatic adenopathy
	Medial and lateral retropharyngeal nodes	Lymphoma
Perivertebral space	Prevertebral/paravertebral muscles	Abscess/osteomyelitis
	Cervical vertebra	Osseous metastasis
	Phrenic and cervical nerves	Schwannomas/neurofibromas

[a]These spaces have been discussed in details in chapters elsewhere in the book

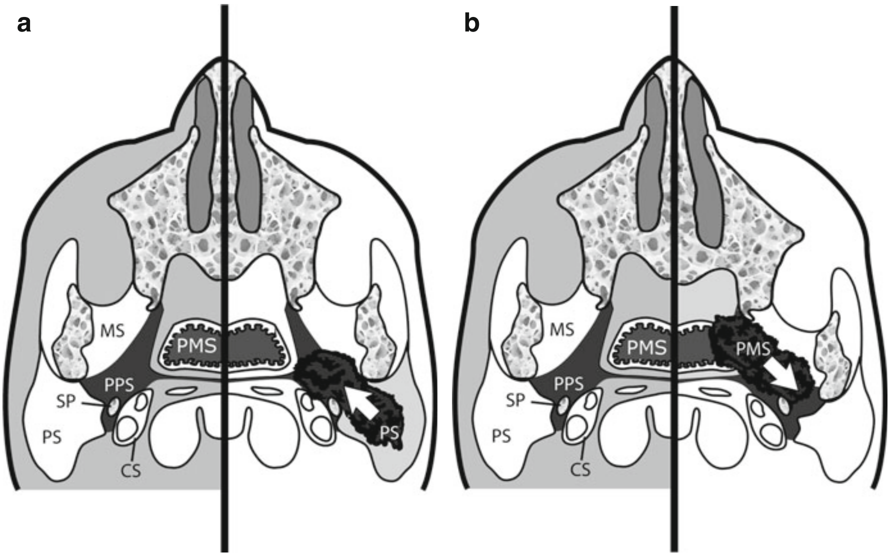


Fig. 1.2 Displacement of fat in the parapharyngeal space (PPS) by lesions in adjacent spaces which are masticator space (MS), parotid space (PS), carotid space (CS), and the pharyngeal mucosal space (PMS). The styloid process (SP) is along the posterior aspect of the parapharyngeal space. These include anteromedial displacement (**a**) by a lesion arising from the deep lobe of the parotid gland from PS (such as a pleomorphic adenoma), posterolateral displacement (**b**) of the fat by a pharyngeal mucosal space (PMS) lesion (such as a nasopharyngeal carcinoma), posteromedial displacement (**c**) from a masticator space (MS) lesion, or anterior displacement (**d**) from a lesion arising from the carotid space (CS) lesion (nerve sheath tumors or paragangliomas)

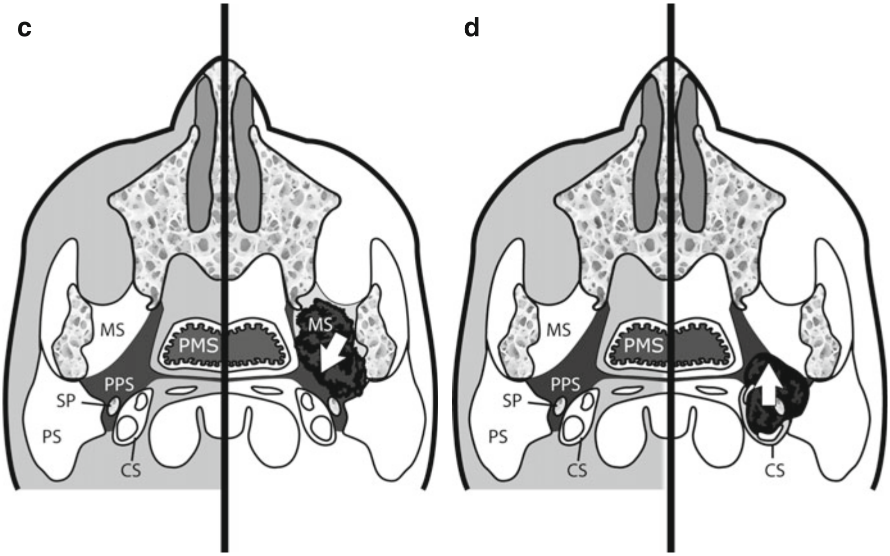


Fig. 1.2 (continued)

Box 1.2. Lesion Localization in Suprahyoid Neck

Lesion location	Displacement
Pharyngeal mucosal space	Posterolateral displacement of parapharyngeal fat Posterior displacement of styloid process
Masticator space	Posteromedial displacement of parapharyngeal fat Posterior displacement of styloid process
Carotid space	Anterior displacement of parapharyngeal fat and styloid process
Parotid space	Anteromedial displacement of parapharyngeal fat
Retropharyngeal	Anterolateral displacement of parapharyngeal fat Anterior displacement of styloid process

gland rest. As shown in Fig. 1.3, pleomorphic adenomas are typically well marginated and bright on T2 with heterogeneous enhancement. It is important to distinguish a pleomorphic adenoma arising from a minor salivary gland rest in the PPS from those arising from the deep lobe of parotid gland as this has significant surgical implications: masses centered in the PPS should be fully encompassed by PPS fat. The presence of small branches from V3 gives rise to neurogenic tumors (schwannomas and neurofibromas), which tend to be well defined, but are typically less bright on T2 than pleomorphic adenomas; they may, however, be indistinguishable. This distinction is not vital, as long as the radiologist is confidently able to place the mass in the PPS. Lipomas are rare encapsulated fatty tumors that follow

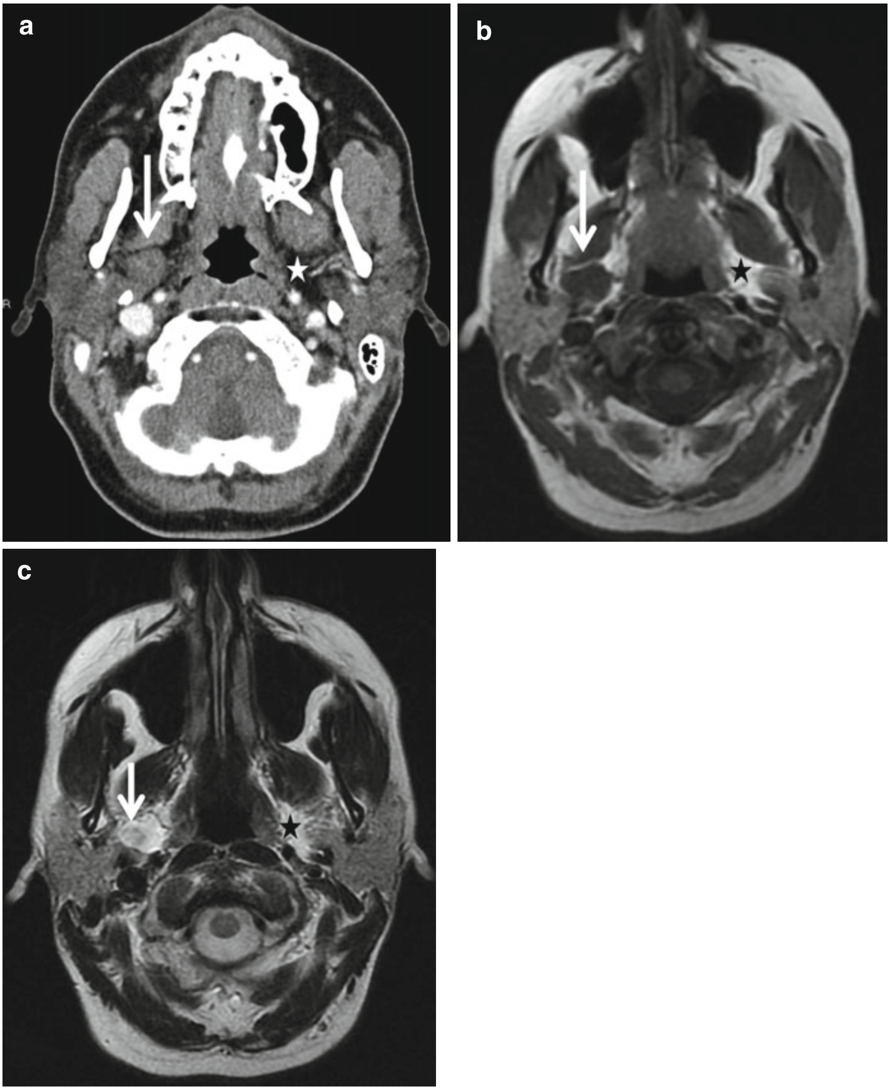


Fig. 1.3 Pleomorphic adenoma. Axial CT (**a**) and T1- and T2-weighted MR images (**b** and **c**) display a well-circumscribed lesion centered within the right parapharyngeal space (*white arrow*). Note the thin rim of fat surrounding the lesion. The contralateral normal left parapharyngeal space demonstrates normal fat (*star*). Fat appears hypodense on CT (with negative Hounsfield Units) and is hyperintense on both T1 and T2 sequences. Pleomorphic adenomas usually appear hyperintense on T2-weighted sequences, as seen on image (**c**)

fat signal and density on all MR sequences and CT, respectively. Malignant neoplasms, such as adenoid cystic carcinoma and mucoepidermoid carcinoma are uncommon. As in other spaces, malignant neoplasms are infiltrative and demonstrate avid, though not always uniform, enhancement.

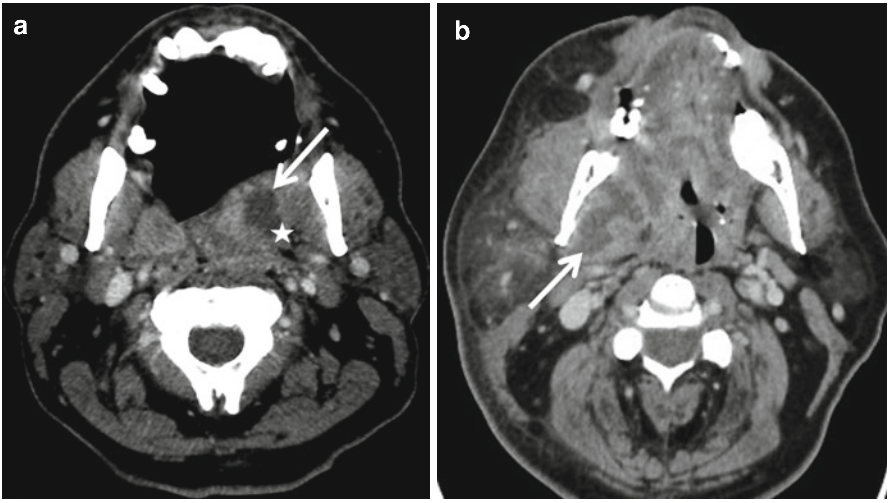


Fig. 1.4 Peritonsillar abscess. Axial contrast-enhanced CT shows low-density irregular left peritonsillar abscess (*white arrow* in **a**) with extension in the left parapharyngeal space (*star*). The right tonsil demonstrates mildly striated enhancement, which is suggestive for inflammation. Another case (**b**) shows extension from the right masticator space (*arrows*) due to right mandibular periodontal disease

Infection of the PPS is most commonly the result of direct spread from the pharyngeal mucosal space (tonsillitis) or the masticator space (sinus or odontogenic infection) (Fig. 1.4). Additionally, infections can spread to the PPS via direct communication with the submandibular space. Early infection may show only mild fat stranding or inflammation. A thicker rim of enhancement and a central necrotic core consisting of fluid and debris can distinguish late infection with abscess formation. These patients are usually acutely ill, so clinical setting can help establish the diagnosis.

The most common congenital lesions of the PPS include the second branchial cleft cyst (BCC) and venolymphatic malformations. The second branchial sinus extends from the skin of the lateral neck to the palatine tonsil. A second BCC may occur anywhere along this tract, typically at the anterior margin of the sternomastoid near the angle of the mandible. Rarely, a second BCC may arise within the PPS. As in its more typical location at the angle of the mandible, a second BCC in the PPS should be cystic with a thin, nonenhancing rim (Fig. 1.5). Venolymphatic malformations are typically lobular, transspatial masses with cystic components. The presence of phleboliths, best depicted on CT, is specific for this entity.

1.2.2 Masticator Space

1.2.2.1 Anatomy

At the angle of the mandible, the SLDCF splits into superficial and deep leaflets to enclose the masticator space. The superficial leaflet extends superiorly to enclose the zygomatic arch and temporal fossa. The deep leaflet extends cranially to the

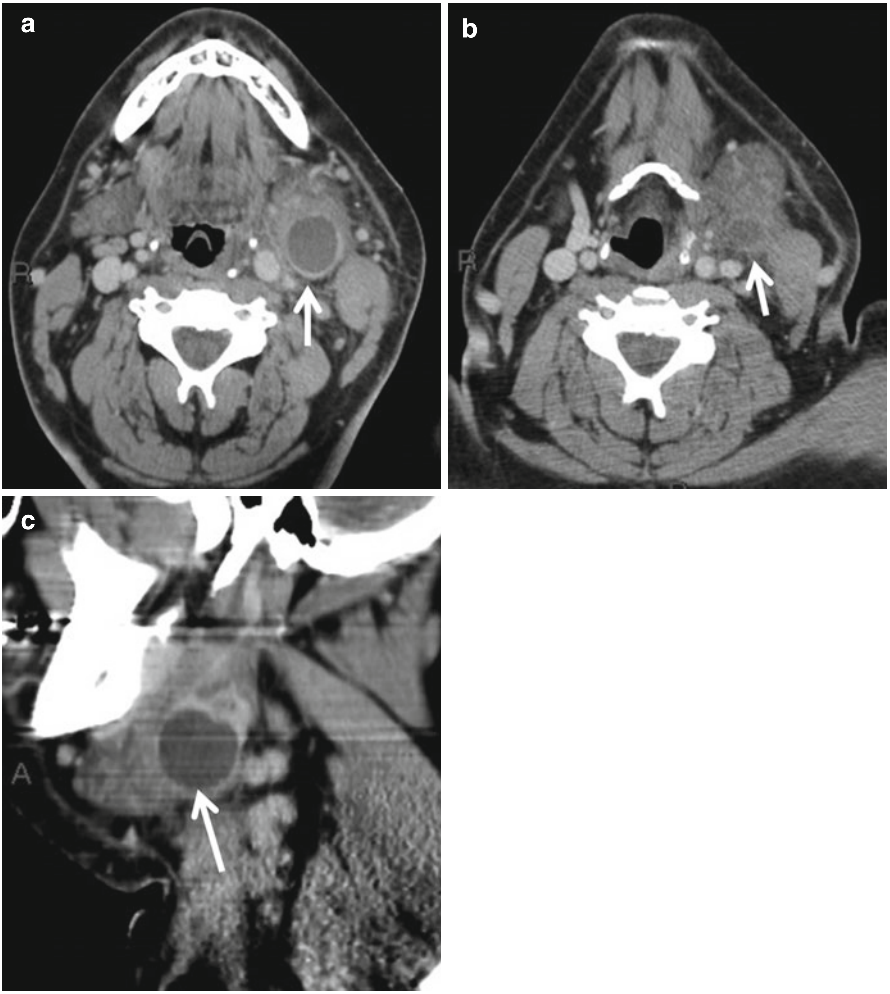


Fig. 1.5 Infected second branchial cleft cyst. Axial and sagittal contrast-enhanced CT images (**a**, **b**) show an infected second branchial cleft cyst (*arrow*) involving the left inferior parapharyngeal space. The lesion is in between the submandibular gland anteriorly, carotid sheath posteriorly, and the sternocleidomastoid laterally. The sagittal images (**c**) demonstrate the lesion at the angle of the mandible, a common location (*arrow*)

skull base from the medial pterygoid plate to the sphenoid spine, enclosing the foramen ovale within the masticator space.

The masticator space (consisting of the supra- and infrazygomatic segments) extends from the temporalis muscle insertion high on the parietal calvarium to the angle of the mandible; this is important to remember, as there is a tendency to only consider the infrazygomatic portion of the space when evaluating imaging. The mandibular ramus and posterior body, muscles of mastication, branches of V3, and inferior alveolar artery and vein are included within this space (Box 1.1).

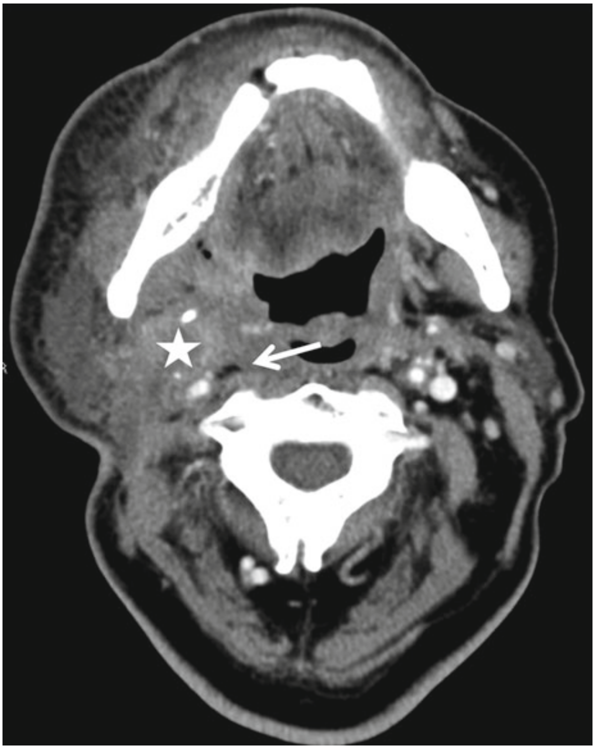


Fig. 1.6 Tumor masticator space. Recurrent tumor in the right masticator space (*star*) with involvement of the right parapharyngeal and carotid spaces. Note the minimal amount of preserved fat along the posterior aspect of the right parapharyngeal space (*arrow*)

Masses of the masticator space should be centered within the muscles of mastication or arising from the posterior body or ramus of the mandible. The mass should displace the PPS posteriorly and medially (Fig. 1.6). When there is concern for a malignant process in the masticator space, it is important to evaluate the entire course of V3 from the Meckel's cave through foramen ovale for signs of perineural spread.

1.2.2.2 Pathology

When a patient presents with trismus, the masticator space must be carefully evaluated. Trismus is especially worrisome in a patient with an oral cavity or oropharyngeal cancer and may imply invasion of the pterygoid musculature. Inflammation in the masticator space, most commonly odontogenic in origin, can also irritate the muscles of mastication and cause trismus. However, there are other considerations within the masticator space, as indicated in Box 1.1.

Odontogenic abscesses, particularly from the third molar, are the most common masses of the masticator space. As with other abscesses, CT or MR should demonstrate a thick rim of enhancement with central necrosis (Fig. 1.7). To establish the abscess as odontogenic, CT is recommended to evaluate the dentition for periapical disease and cortical disruption. Alternatively, clinical history of a recently extracted tooth can suggest the diagnosis. Documentation of the tooth or teeth of origin will

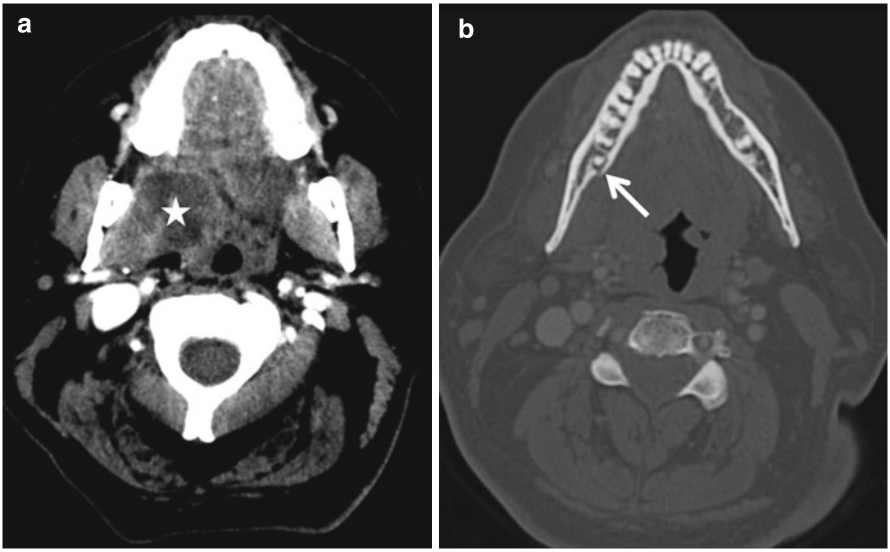


Fig. 1.7 Abscess masticator space. Rim-enhancing abscess (*star* in **a**) within the right masticator space secondary to spread from periodontal disease involving the mesial root of right mandibular molar with loss of lingual cortex (*arrow* in **b**)

help guide treatment. It is then important to evaluate the mandible for signs of osteomyelitis, including mottled bone destruction and periostitis as this may necessitate prolonged antibiotic therapy.

Benign soft tissue tumors in the masticator space include neurogenic tumors and leiomyomas. Schwannomas and neurofibromas may arise anywhere along V3; these are ovoid, enhancing masses along its course. Occasionally, they can encroach upon and expand foramen ovale or the inferior alveolar canal. They may also occur elsewhere in the space if they originate from smaller branches of the nerve. If neurogenic tumors grow adjacent to bone, smooth remodeling is noted. Leiomyomas are rare and are indistinguishable from neurogenic tumors.

Benign and malignant mandibular tumors may present as masticator space masses and will be discussed in greater detail in the chapter on Jaw imaging (Chap. 11).

Primary malignant tumors of the masticator space are rare, but rhabdomyosarcoma, leiomyosarcoma, osteosarcoma, and liposarcoma can occur. A necrotic heterogeneous masticator space mass in a young patient is likely to be a rhabdomyosarcoma. Liposarcomas, when relatively well differentiated, may contain macroscopic fat; when poorly differentiated, they resemble other sarcomas. Osteosarcoma can have a varied radiographic appearance ranging from osteolytic to mixed to osteogenic pattern of bone. New bone formation when identified, is helpful in narrowing the diagnosis (Fig. 1.8). The presence of an aggressive tumor in the masticator space warrants careful evaluation for perineural spread and for direct invasion of contiguous spaces. Tumors in the masticator space may gain access to the middle cranial fossa through the foramen ovale.

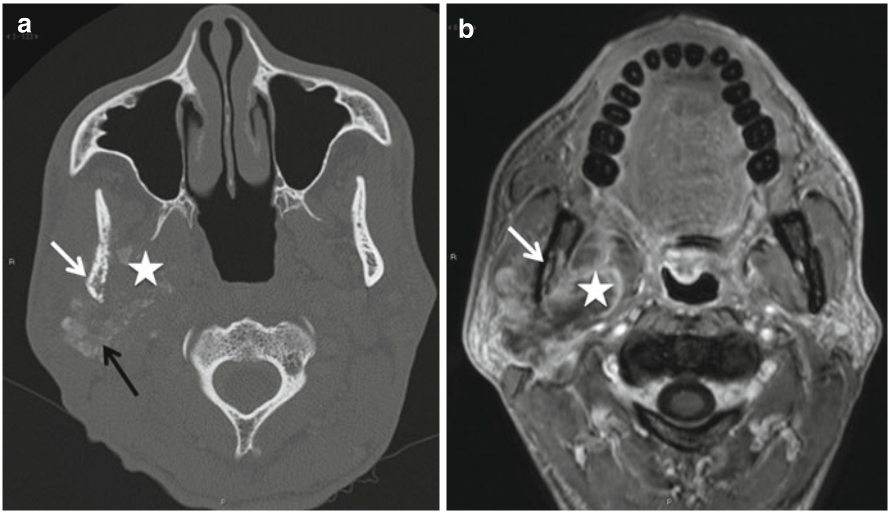


Fig. 1.8 Mandibular osteosarcoma. Axial CT (**a**) and post-contrast MR (**b**) show a heterogeneous aggressive tumor within the right masticator space arising from the right mandible (*white arrow*). Note the large soft tissue component of the tumor completely effacing the right parapharyngeal space along with new bone formation on the CT (*black arrow* in **a**) (*white star* in **a** and **b**)

Other lesions of the masticator space include venolymphatic malformations, which tend to be lobular and transspatial with scattered cystic spaces. Specific to the masticator space is benign hypertrophy of the muscles of mastication caused by bruxism. Typically, this is bilateral but can be unilateral; there should be no unusual enhancement or asymmetric edema.

1.2.3 Carotid Space

1.2.3.1 Anatomy

The fascial anatomy of the carotid space is complex, including layers from the SLDCF, MLDCF, and DLDCF. Grossly, the SLDCF forms the lateral wall, the DLDCF forms the posterior wall, the MLDCF forms the anterior wall, and the medial wall is comprised of either or both of the MLDCF and DLDCF. Below the level of the carotid bulb, the fascia completely encloses the carotid space. Above the bifurcation, however, there are areas of dehiscence of the fascia, providing a means for direct extension of an infiltrating mass into or out of the carotid space.

The carotid space begins at the skull base and extends throughout the entire length of the neck to the aortic arch. At the skull base, the fascial envelope encloses the carotid canal, jugular foramen, and hypoglossal canal. Within this space are the common and internal carotid arteries, internal jugular vein (IJV), cranial nerves IX through XII, the sympathetic plexus, and numerous lymph nodes (Box 1.1). Below

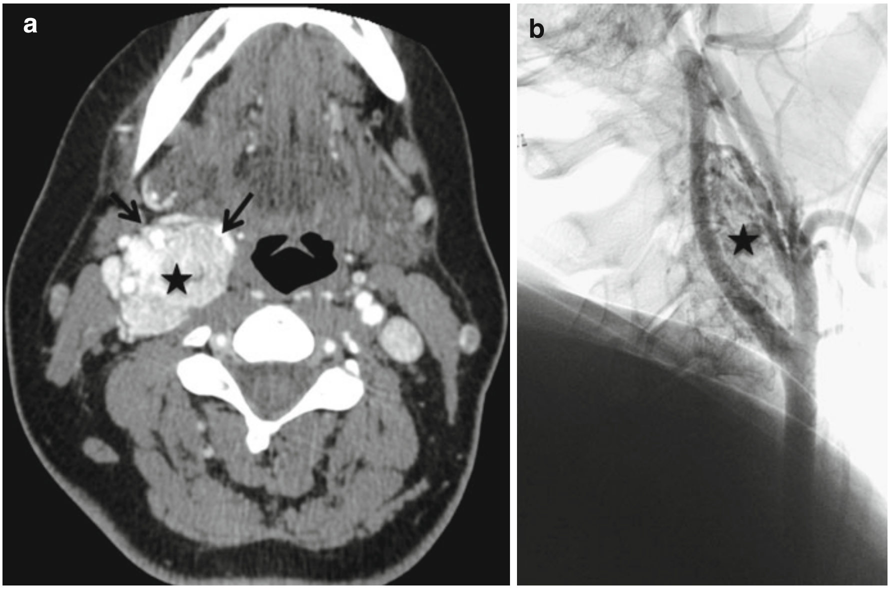


Fig. 1.9 Carotid body tumor. Axial CT (**a**) and catheter angiogram (**b**) demonstrate the intense enhancement along with the hypervascular blush of this lesion within the right carotid space (*black star*). The lesion splays the carotid vessels (*small arrows*) and completely effaces the right parapharyngeal fat which is displaced anteriorly

the level of the hyoid, only the vagus nerve remains with the carotid arteries and IJV within the carotid space.

Masses arising within the carotid space may displace the PPS or styloid process anteriorly and the posterior belly of the digastric muscle or parotid gland laterally (Fig. 1.9). A carotid space mass may engulf, displace, or splay the carotid arteries and IJV. Observation of the effect on the vessels can suggest a foremost diagnosis.

1.2.3.2 Pathology

The presence of the carotid artery, cranial nerves, paraganglia, and sympathetic plexus give rise to several masses unique to this space (Box 1.1). Schwannomas and paragangliomas are the most common benign tumors of the carotid space. Schwannomas may arise from any of the cranial nerves or the sympathetic plexus within the carotid space. Classically, schwannomas appear well circumscribed and enhance uniformly. However, cystic degeneration may result in a heterogeneous appearance with variable enhancement. The vagus nerve (X) traverses the carotid sheath between the common carotid artery and the IJV. Thus, a vagal schwannoma will often splay the common carotid artery and the IJV (Fig. 1.10a). The sympathetic chain courses along the posteromedial margin of the carotid vessels so sympathetic chain schwannomas displace both vessels but do not increase the distance between them (Fig. 1.10b). Paragangliomas include glomus

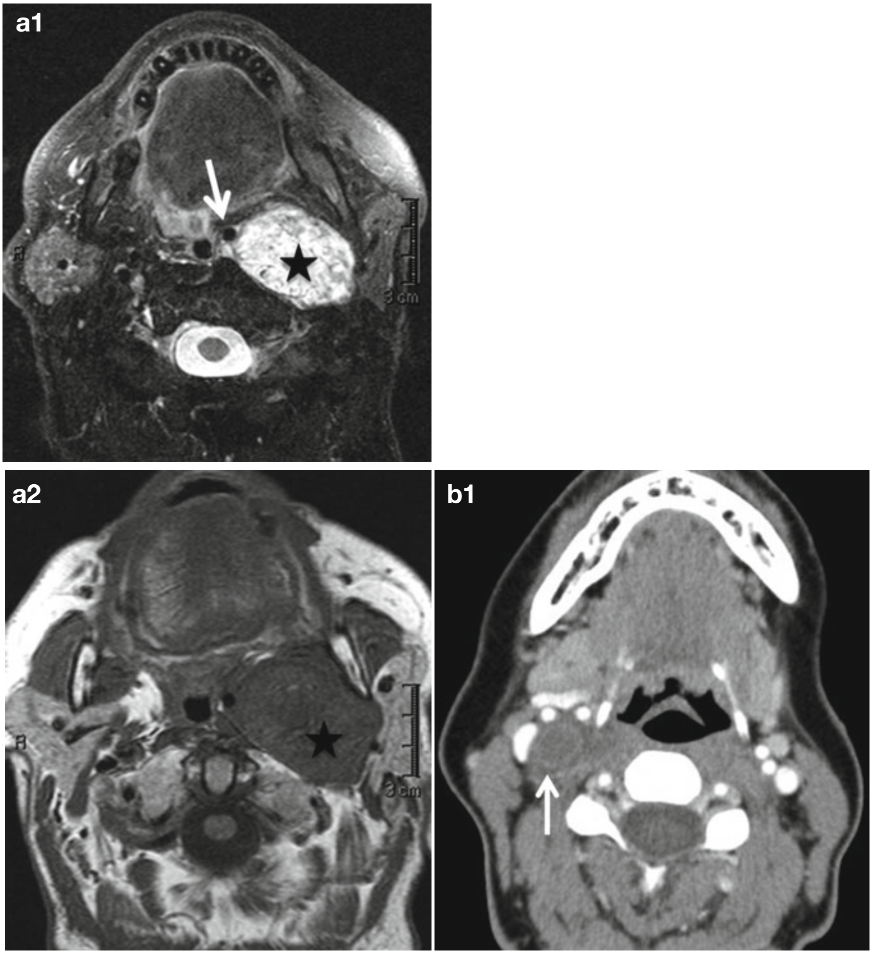
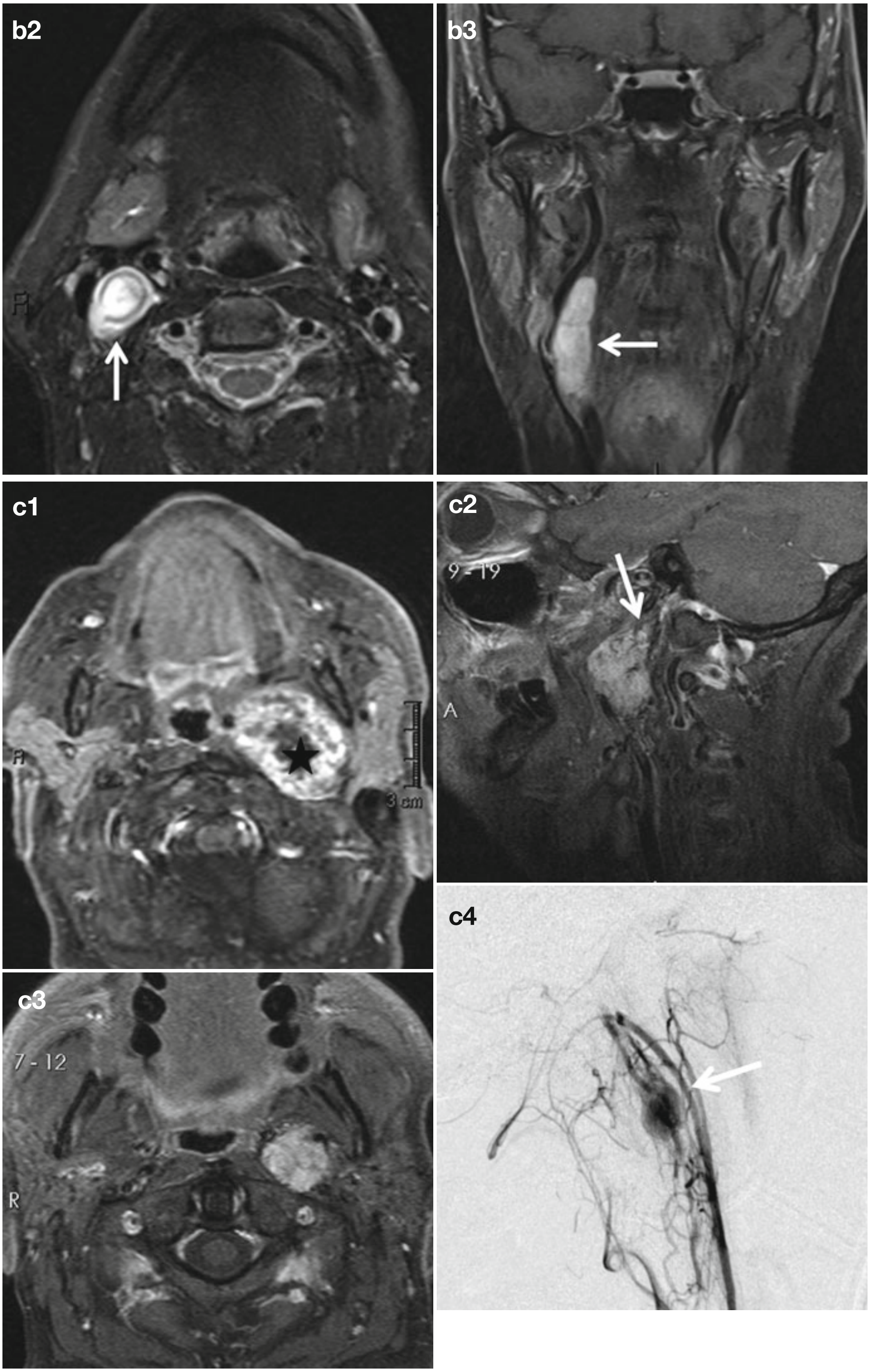


Fig. 1.10 (**a**) Vagal schwannoma. Axial T2 and T1 (**a1** and **a2**) MR images of a left carotid space vagal schwannoma, which is T2 hyperintense, with heterogeneous peripheral enhancement and central necrosis. (not shown here). The mass displaces the internal carotid artery anteromedially (*arrow* in **a**) and completely effaces the internal jugular vein. (**b**) Sympathetic trunk schwannoma. CT (**b1**) and MR images (**b2** and **b3**) of a hypodense right carotid space well-defined lesion, which is T2 hyperintense and has a tubular configuration, best appreciated on the coronal post-contrast sequences (*arrow* in **b3**). The internal and external carotid branches are displaced anteriorly, while the internal jugular vein is displaced laterally. On resection, this was a schwannoma arising from the sympathetic trunk. (**c**). Glomus vagale. Sagittal and axial post-contrast MR images (**c1** and **c2**) of a left-sided glomus vagale paraganglioma, as a heterogeneously enhancing mass in the left carotid space. This lesion extends superiorly towards the jugular foramen (*arrow* in **c2**) and shows a focal blush (*arrow* in **c4**) on the left common carotid angiogram. These lesions usually arise within 1–2 cm below the skull base. (**d**) Carotid body tumor. Intensely enhancing left carotid space mass lesion (**d1**, **d3**, **d4**, **d5**), with small flow voids (**d2**) along with the characteristic location at the carotid bifurcation, splaying the internal and external carotid branches on the MR angiogram (**d4**) and the catheter angiography (**d5**), consistent with a carotid body paraganglioma



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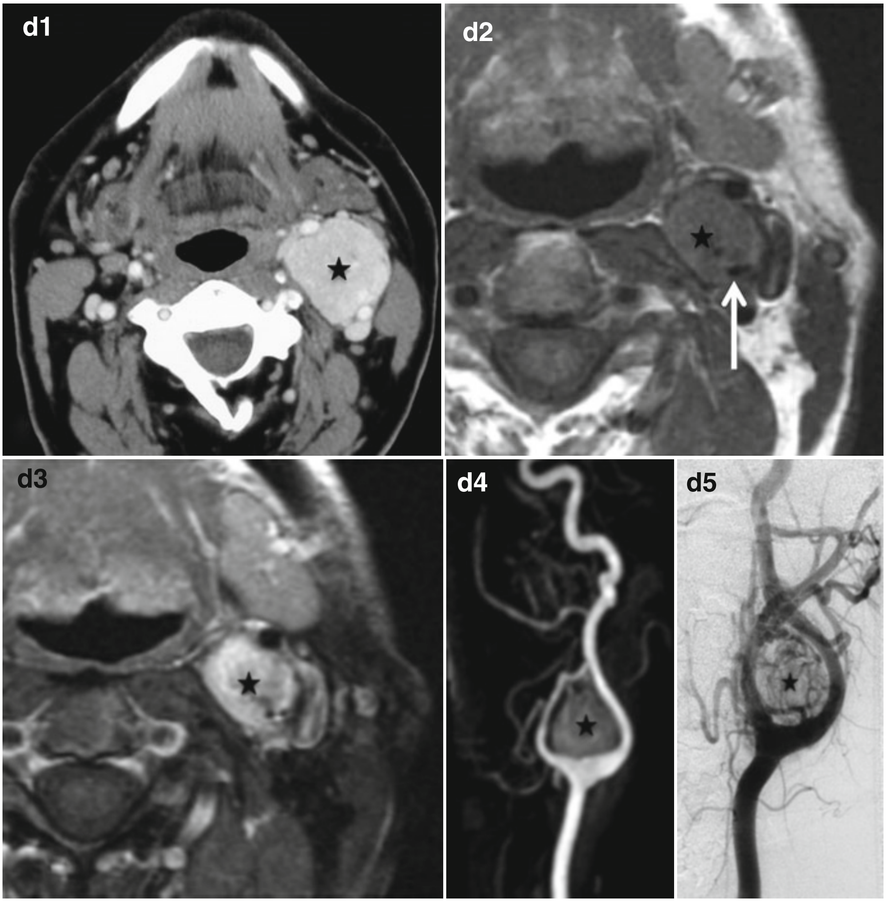

Fig. 1.10 (continued)

jugulare, glomus vagale, and carotid body tumors. On unenhanced MRI, flow voids can often be identified, giving them a salt-and-pepper appearance. However, these are not always evident, especially in smaller tumors. Upon administration of gadolinium, paragangliomas demonstrate rapid wash-in and wash-out as opposed to the more slow and steady enhancement of a schwannoma. Glomus jugulare tumors may extend through the jugular foramen, invading the jugular vein and often leading to mottled bony destruction of the foramen itself. Glomus vagale tumors typically occur several centimeters below the skull base (Fig. 1.10c). Carotid body tumors occur at the carotid bifurcation and tend to splay the internal and external carotid arteries (Fig. 1.10d). Due to their origin at the crux of the carotid bifurcation, it is important to comment on arterial involvement: tumors that are adherent to the artery, partially surround the vessel, or

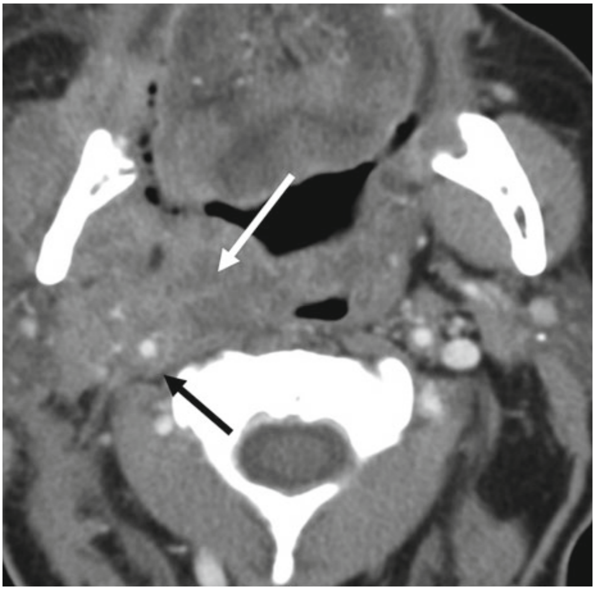

Fig. 1.11 Carotid encasement. Contrast-enhanced axial CT image in a patient with a large right tonsillar SCC (*white arrow*) that extends to the skull base and encases the right internal carotid artery (*black arrow*)

completely encase the artery put the patient at higher risk for injury to the artery and cranial nerves during resection.

Primary malignant neoplasms are particularly rare within the carotid space. However, involvement of the space from metastatic lymphadenopathy from squamous cell carcinoma or by lymphoma can occur. When evaluating lymphadenopathy, particularly with extracapsular spread, it is important to comment on the extent of involvement of the carotid artery. If less than 270° of the circumference of the artery is involved, the surgeon can generally resect the mass without sacrificing the artery (Fig. 1.11).

Commonly, "masses" of the carotid space will be vascular in etiology. Fibrofatty atherosclerotic disease of the carotid artery can be mistaken for a mass. Ectasia or fusiform or saccular aneurysmal dilation of the carotid artery may also be mistaken for a true mass. In each of these cases, the mass will typically be pulsatile and vascular imaging will demonstrate the "mass" as intraluminal, clinching the diagnosis (Fig. 1.12). IJV thrombosis may also simulate a mass (Fig. 1.13). In a patient with a recent indwelling venous line, thrombosis should be considered and US is very good for screening. However, if the thrombus propagates beyond the thoracic inlet and if knowledge of the extent will help direct treatment, CT or MRI will be necessary. Infrequently, a patient may present with tenderness over the carotid bifurcation and be diagnosed with carotidynia. Commonly, there is no associated radiographic or pathologic finding associated with the neck pain. However, CT or MR may occasionally demonstrate abnormal enhancing tissue surrounding the symptomatic carotid artery corresponding to the focus of tenderness (Fig. 1.14).

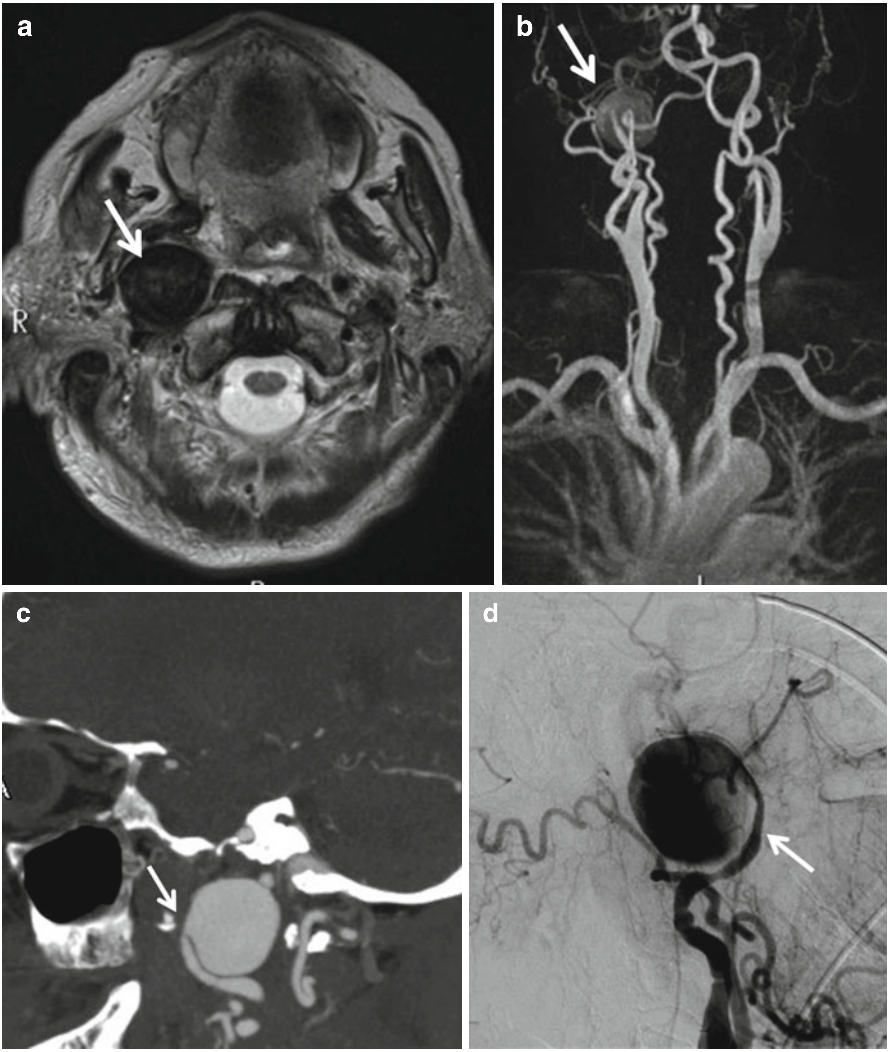

Fig. 1.12 Internal carotid artery aneurysm. Axial T2-weighted MR (**a**) shows a T2 hypointense lesion within the right carotid space, which clearly appears to arise from the right internal carotid artery (*white arrow*) on the MR angiogram of the neck (**b**), CT angiogram (**c**), and the catheter angiogram (**d**)

1.2.4 Posterior Spaces

1.2.4.1 Anatomy

The posterior spaces of the neck include the retropharyngeal space, danger space, and the perivertebral or prevertebral space. As these three spaces are in continuity and share similar fascia, anatomic boundaries, and pathologies, they will be discussed together.

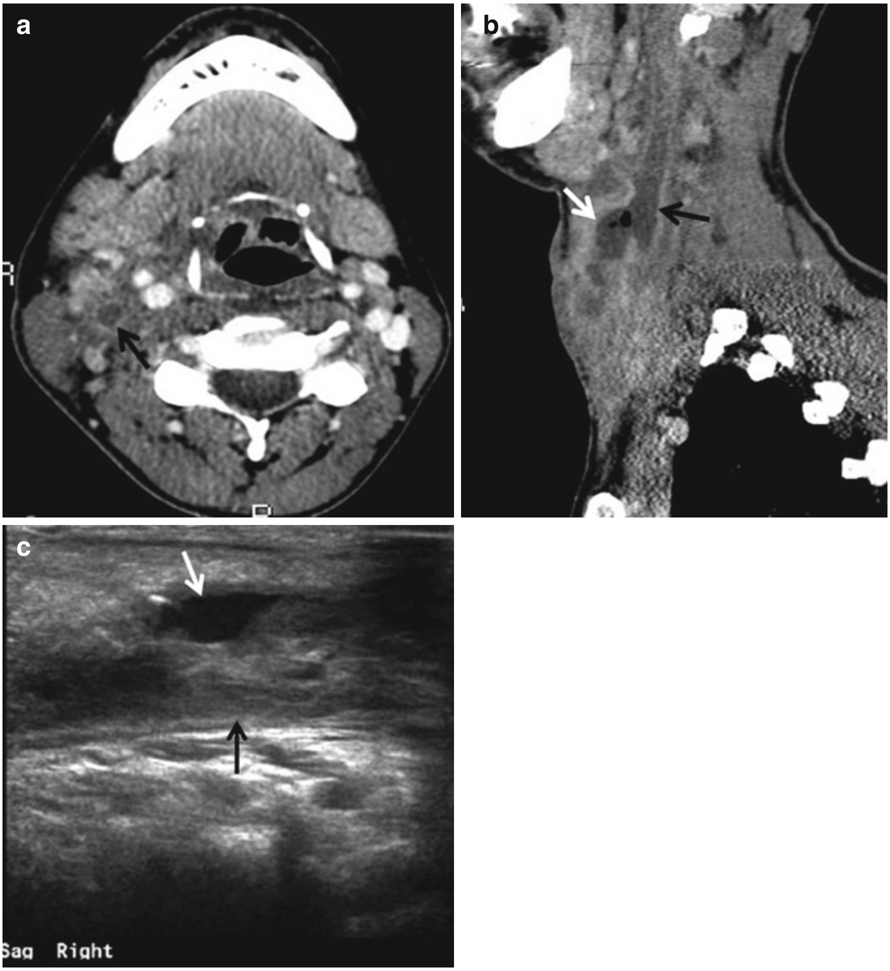

Fig. 1.13 Internal jugular vein thrombosis with abscess. Axial and sagittal CT (**a**, **b**) and sagittal USG (**c**) demonstrate thrombosed right internal jugular vein (*black arrow*) in this young patient with history of intravenous drug abuse. The patient injected the drug directly into her right internal jugular vein. Note the abscess anterior to the thrombosed vein (*white arrow* in **b** and **c**)

The most anterior of the three spaces is the retropharyngeal space, which courses along the posterior margin of the pharyngeal mucosal space and extends from the skull base to T3. The retropharyngeal space is bordered anteriorly by the visceral fascia, which is a component of the MLDCF, and posteriorly by the alar fascia, a component of the DLDCF. The danger space is a potential space that lies immediately posterior to the retropharyngeal space and is sometimes referred to as the posterior compartment of the retropharyngeal space. The danger space extends from the skull base to the diaphragm and is bordered anteriorly

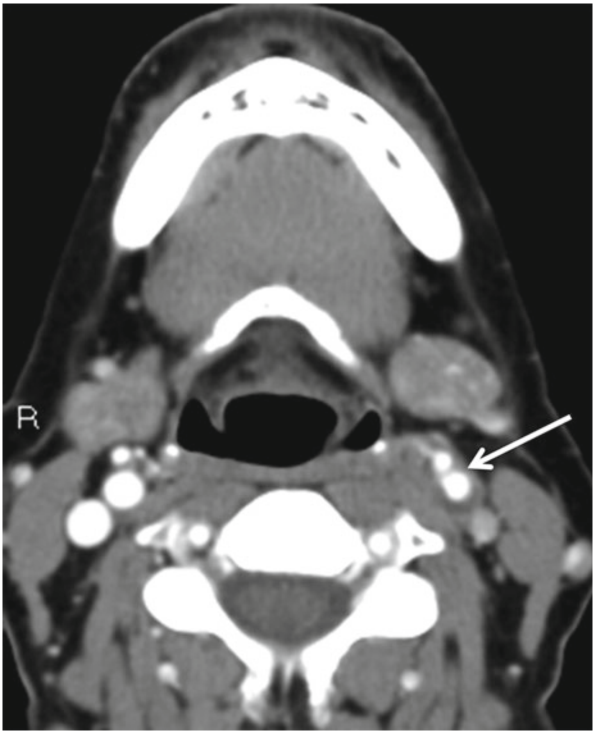

Fig. 1.14 Carotidynia. Axial CT with contrast clearly demonstrates a small cuff of soft tissue (*white arrow*) surrounding the left carotid artery in this patient with pain overlying the left neck in the same location. This is a self-limited condition and resolves in a few weeks with supportive treatment

by the alar fascia and posteriorly by the prevertebral fascia, both components of the DLDCF. The perivertebral space extends from the skull base to the upper mediastinum and is completely enclosed by the prevertebral fascia, a component of the DLDCF.

The retropharyngeal space can be divided into a suprahyoid component and an infrahyoid component. The infrahyoid retropharyngeal space is made up only of fat, while the suprahyoid portion contains fat and lymph nodes (Box 1.1). The lymph nodes can be divided into medial and lateral groups. The medial nodes are located along the midline, but are not always present. The lateral nodes can be found overlying the vertebral transverse processes.

The danger space is a potential space and has no contents; it only becomes evident when invaded or edematous.

The perivertebral space was classically referred to as the prevertebral space, but more recently has been described as the perivertebral space to account for the inclusion of the paraspinal musculature and the posterior elements of the vertebral bodies. However, discussions of the perivertebral space typically refer to the prevertebral component, which is comprised of the prevertebral and scalene muscles, the vertebral artery, the brachial plexus, phrenic nerve, the vertebral body, and the intervertebral disc (Box 1.1).

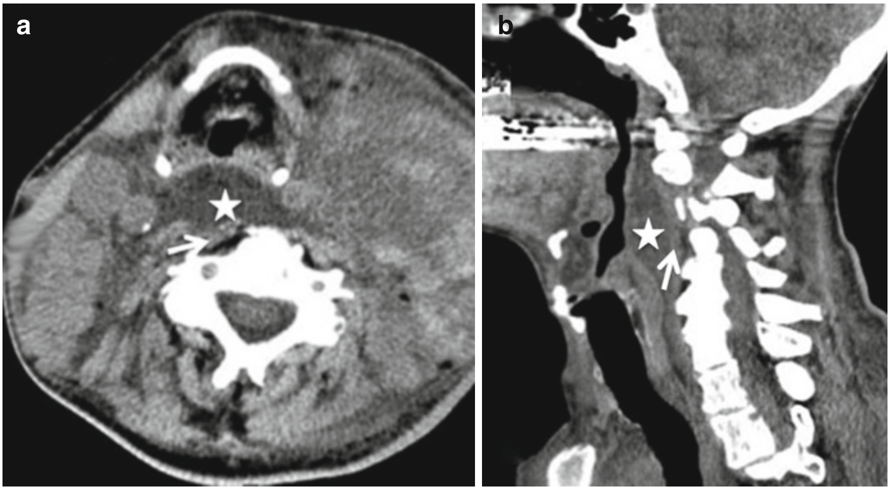

Fig. 1.15 Retropharyngeal edema. Axial and sagittal CT images (**a**, **b**) show large retropharyngeal effusion (*white star*) in this patient with bilateral pathological adenopathy status postradiation therapy. This is not an uncommon situation and retropharyngeal effusions have been described in various other infectious and inflammatory conditions. Note its location anterior to the prevertebral muscles (*small white arrows*)

Differentiating masses of the retropharyngeal space from those of the perivertebral spaces can best be accomplished by observing the effect on the prevertebral musculature. Retropharyngeal lesions arise in the potential space between the aerodigestive tract and the prevertebral muscles, so lesions in this space should displace the musculature posteriorly. The perivertebral space is a potential space between the prevertebral musculature and the anterior column of the vertebrae. Lesions in this space should displace the prevertebral musculature anteriorly. If a mass directly involves the vertebral body, it can be conclusively described as a perivertebral space lesion.

1.2.4.2 Pathology

The differential diagnosis for a mass centered in the retropharyngeal space is limited. Most commonly, visualization of the retropharyngeal space is due to the presence of edema from radiation treatment, trauma, or infection (Fig. 1.15). Discrete lesions of the retropharyngeal space are most commonly reactive or suppurative nodes resulting from pharyngitis or tonsillitis. If reactive, the nodes should appear well defined, round, and homogeneous. Suppurative nodes can appear similar but may progress to a more heterogeneous density, eventually becoming cystic. If left untreated, suppurative nodes may rupture, forming a retropharyngeal abscess (Fig. 1.16). Differentiation of an abscess from edema can often be made based on past medical history and clinical symptoms. CT will show a peripherally enhancing fluid collection, often in conjunction with tonsillitis or pharyngitis if an abscess is present.

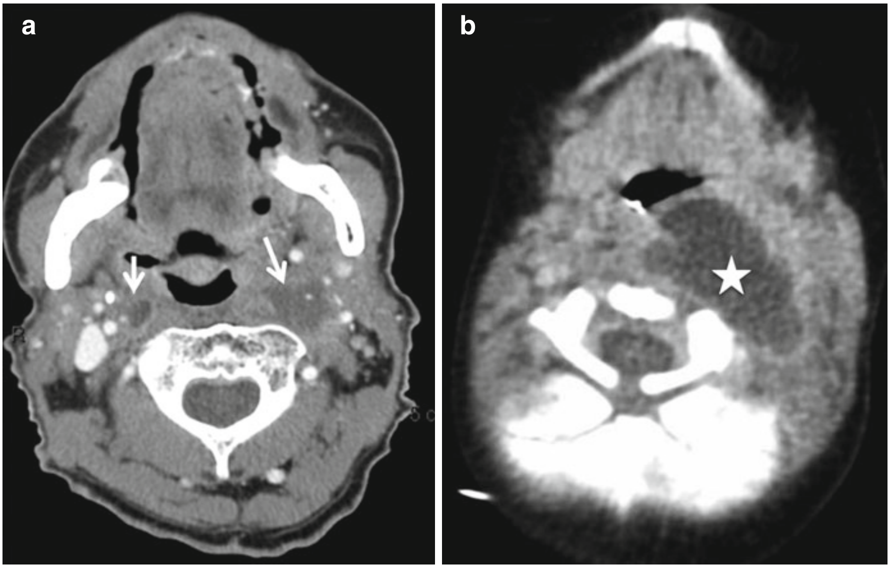

Fig. 1.16 Suppurative retropharyngeal abscess. Axial contrast-enhanced CT (**a**) in this patient shows bilateral suppurative retropharyngeal adenopathy (*white arrow* in **a**). CECT in a different patient (**b**) with shows a large retropharyngeal abscess, presumably originating from a suppurative left retropharyngeal node. The large abscess involves the left parapharyngeal space with mass effect on the airway (*white star* in **b**)

Retropharyngeal lymphadenopathy may be a sign of lymphoma or metastatic disease (Fig. 1.17). While retropharyngeal nodes are not a primary drainage pathway for head and neck cancers, they frequently become involved with recurrences after neck dissection. Initially, the lymph nodes increase in size and appear well rounded. With continued growth, they may become necrotic. Eventually, the capsule of the lymph node is disrupted, and the mass can appear very irregular.

The danger space is a potential space, only becoming evident when edema or abscess dissects between the alar fascia and the prevertebral fascia. An infection in the danger space could directly communicate with the thoracic cavity leading to mediastinitis and pericarditis, hence the name "danger space."

Masses centered in the perivertebral space most frequently arise from the vertebral bodies. Spondylosis is common. Associated anterior disc protrusions or bulges and osteophytes may cause local mass effect. Metastases to the vertebral bodies will replace the normal fatty bone marrow signal, appearing hypointense on T1 with varying levels of enhancement. As with the other posterior spaces, infection should always be considered. However, as opposed to the retropharyngeal and danger spaces where the source of infection is typically oropharyngeal, an infection in the perivertebral space is typically discogenic or vertebral in origin, though involvement of the cervical spine is much less frequent than the lumbar spine. Discitis results in loss of disc height, end plate irregularity, increased T2 signal in the disc space, and

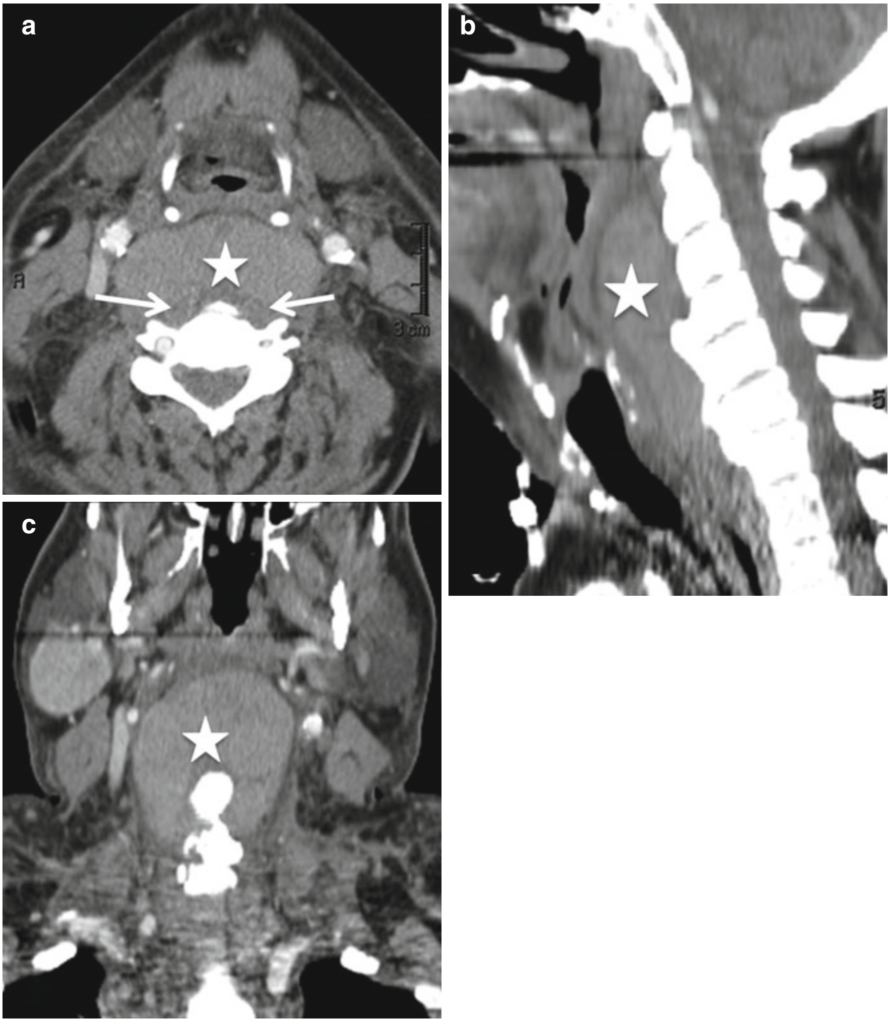

Fig. 1.17 Retropharyngeal lymphadenopathy. Bulky non-necrotic retropharyngeal lymphadenopathy (*white star*) is seen in this patient with non-Hodgkin's lymphoma on the axial, sagittal, and coronal (a, b and c) contrast-enhanced CT images. Note the location of the prevertebral muscles, immediately posterior to the nodal mass (*white arrows* in **a**)

irregular T2 signal and enhancement in the adjacent soft tissues. As the infection spreads to the adjacent vertebral bodies, the end plates demonstrate low T1 signal, high T2 signal, enhancement, and increased end plate irregularity with eventual collapse. Another musculoskeletal cause which is unique to the perivertebral space and can be a cause of diagnostic dilemma on imaging is calcific tendonitis. The reactive retropharyngeal effusion can be mistaken for an infection, and unless the signal dropout from the calcium is recognized, the patient may be subjected to unnecessary

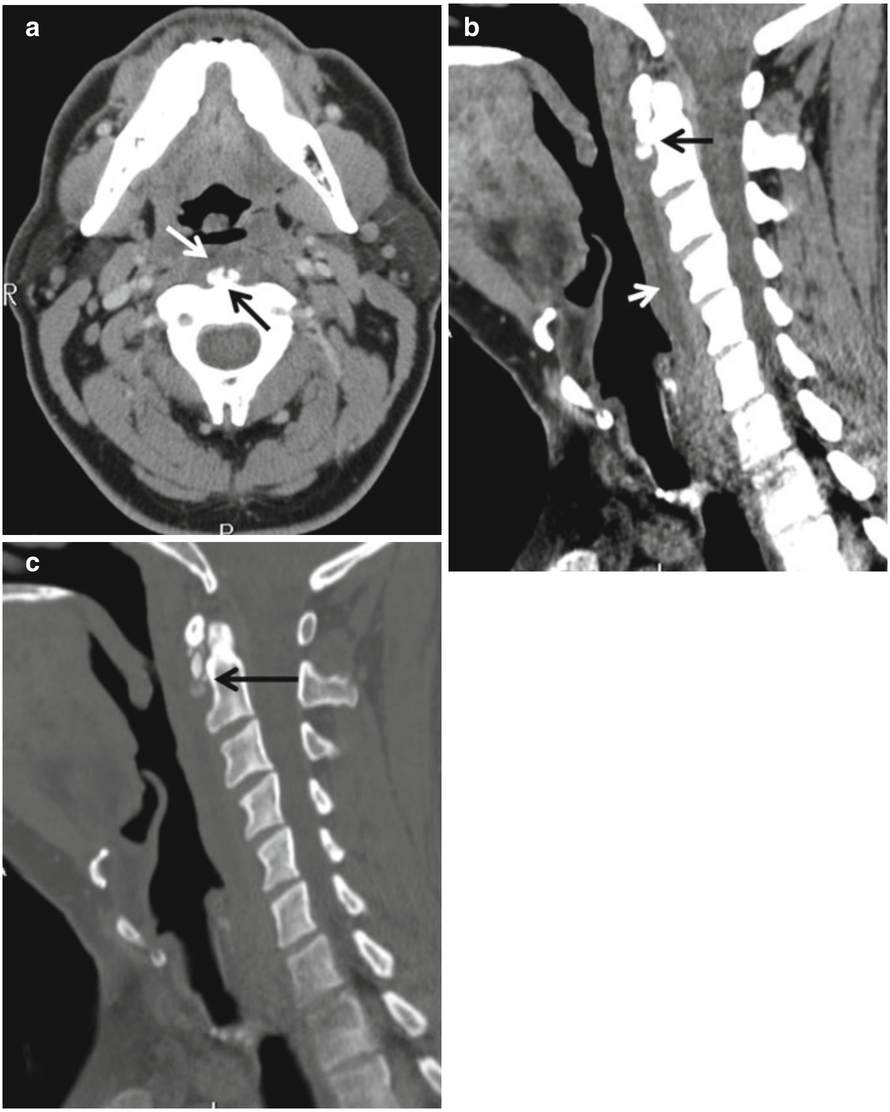

Fig. 1.18 Acute calcific prevertebral tendinitis. Axial (**a**), soft tissue (**b**), and bony window (**c**) sagittal images shows the characteristic calcification (*black arrow*) due to calcium hydroxyapatite in the longus colli muscles at the C2 level with associated retropharyngeal effusion (*white arrow*). This patient presented with headache, slight fever, and other signs concerning for meningitis. This is a self-limiting condition which responds to NSAIDS and rest

treatment (Fig. 1.18). As midline structures, the vertebral bodies may also give rise to chordomas, which are classically T2 hyperintense and enhance avidly.

The cervical spinal nerves, brachial plexus, and the phrenic nerve in the perivertebral space may give rise to neurogenic tumors, including schwannomas and neurofibromas. Patients with neurofibromatosis (NF) types 1 and 2 may develop multiple nerve sheath tumors (Fig. 1.19). The multiplicity of the tumors helps in diagnosis. Neurogenic tumors tend to be T2 hyperintense and enhance avidly. The classical "Target sign" in plexiform neurofibromas on MRI is due to a T2 hypointense core (central fibrocollagenous tissue) with a rim of T2 hyperintense signal (peripheral myxomatous tissue). Other mesenchymal lesions such as sarcomas can also arise in this location from the adjacent muscles and nerves (Fig. 1.20).

1.3 The Surgeon's Perspective

While masses in the PPS are often discovered incidentally on imaging obtained for other reasons, a common presentation is a submucosal oropharyngeal mass. These masses can typically be accessed for core biopsy under imaging guidance, but this may be unnecessary when the diagnosis is reasonably well established by standard imaging and the treatment approach is resection regardless of the pathology. Biopsy is most helpful when there is concern for malignancy, as this will impact the approach and extent of surgery, but as described above, malignancy is uncommon in this space.

The PPS contains the retromandibular portion of the deep lobe of the parotid gland, and when evaluating masses in the PPS, it is important to determine if they originate within the PPS or in the deep lobe of the parotid gland. Tumors of parotid origin require total parotidectomy for removal in order to carefully preserve facial nerve function. Inherent tumors of the PPS do not require parotidectomy (although such an approach may be employed in some cases) and can usually be resected by a transcervical approach. For tumors high in the PPS, transection of the stylomandibular ligament allows anteromedial displacement of the mandible and broader access via the transcervical route. With adequate exposure, removal of well-encapsulated benign tumors is usually straightforward. While mandibulotomy has been described to improve access, removal of the external aspect of the mandibular angle can dramatically improve exposure without disrupting mandibular continuity.

Malignancy involving the PPS is managed with much more aggressive surgical approaches that often require combined parotidectomy, mandibulectomy, and oral/oropharyngeal resection; these require significant reconstructive surgery to restore form and function. Before undertaking such surgery, the pterygoid musculature, skull base, and regional nerves must be examined for tumor spread. Involvement of these structures may not per se make the tumor unresectable, but will dramatically worsen the patient's prognosis, potentially making a palliative approach more appropriate.

Trismus is an important clinical finding that should be explained radiographically. Trismus can be mechanical or secondary to pain/inflammation. When trismus is due to mechanical limitation, it will not be improved by analgesia, sedation, or paralysis; thus, access (e.g., to an intraoral or pharyngeal tumor, to the airway) will not improve in the operating room as it will when mandibular excursion is limited

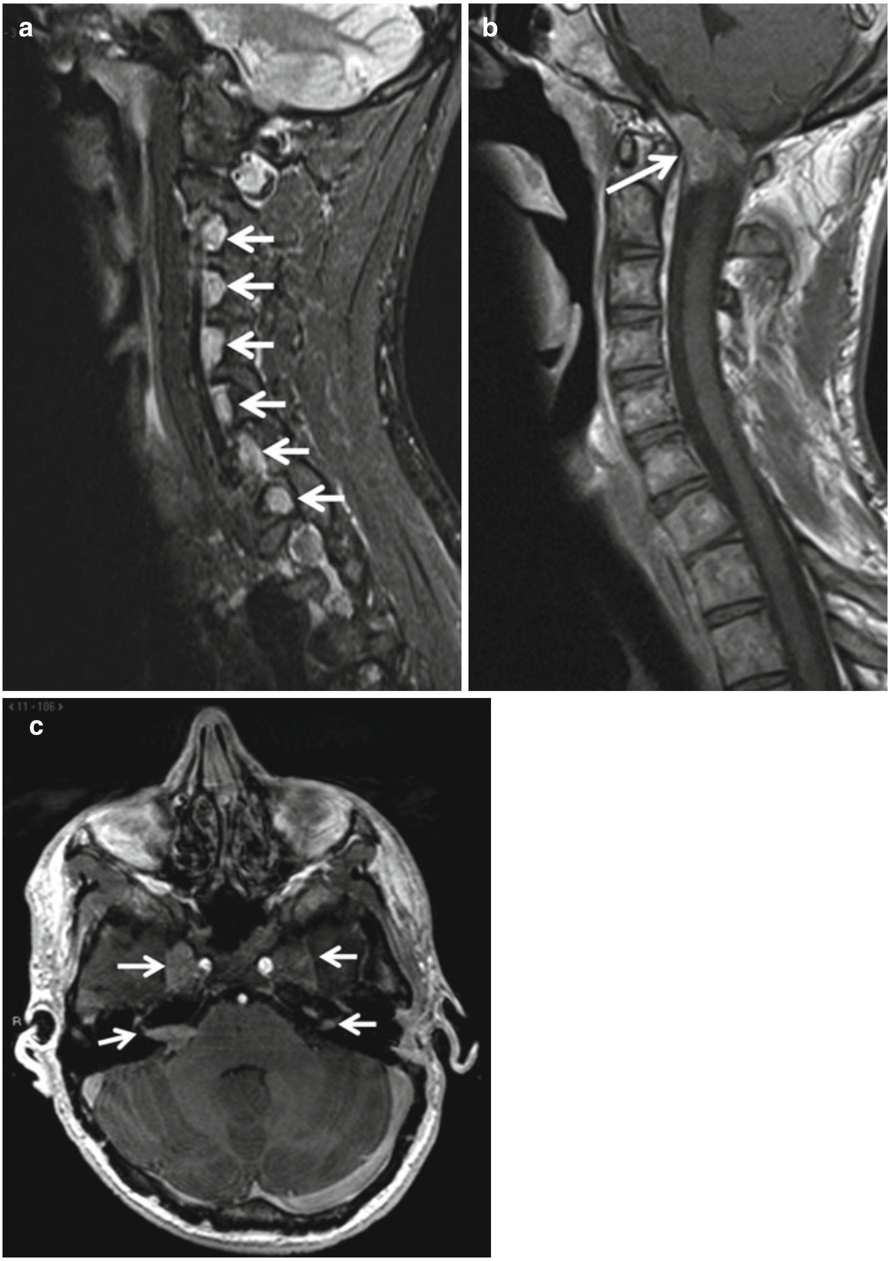

Fig. 1.19 Neurofibromatosis 2. Parasagittal T2, sagittal post-contrast T1, and axial post-contrast T1 sequences demonstrate multiple nerve sheath tumor involving the cervical nerves (*small arrows* in **a**), a skull base meningioma (*arrow* in **b**), and multiple cranial nerve sheath tumors involving bilateral Meckel's cave and internal auditory canals (*small arrows* in **c**)

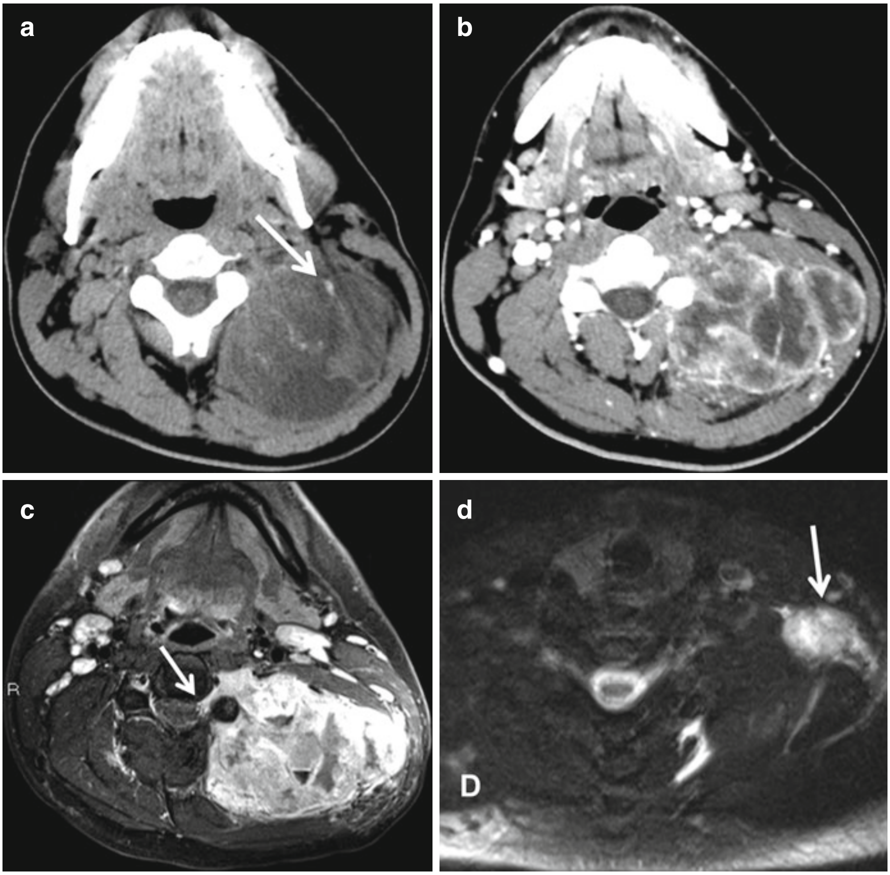

Fig. 1.20 Synovial cell sarcoma. Axial pre- (**a**) and post-contrast (**b**) images in this teenager shows a large lobulated heterogeneously enhancing soft tissue mass in the left posterolateral intramuscular soft tissues, containing scattered calcifications (*arrow* in **a**) and enhancing septations (**b**). Axial post-contrast MR (**c**) shows the intraspinal extension of the lesion, (*arrow* in **c**) while a pathological level V node is seen on the axial T2 fast saturated sequences (*arrows* in **d**)

by pain or inflammation. Mechanical limitation of jaw excursion may warrant an endoscopic approach to airway management or even an awake tracheotomy in some cases, and it is crucial to be aware of this before attempting a standard approach to airway management.

Management of benign tumors in the carotid space is based on diagnosis and symptoms. While paragangliomas are often treated without significant morbidity, resection of neurogenic tumors will almost always result in neurologic functional deficits. Thus, treatment of neurogenic tumors is often delayed until symptoms are noted. Since many of these tumors are discovered incidentally and grow slowly (or not at all), they are often observed for a period of time (6–12 months) to determine their growth rate before making treatment decisions. In such cases, it is important for the radiologist to compare the present images to previous studies to determine the rate of change over time. Tumors in the carotid space are often quite vascular, and particularly if they are larger or close to the skull base resulting in somewhat more difficult access, it can be valuable to consider preoperative embolization to reduce intraoperative bleeding.

Evaluation and management of retropharyngeal infections should be prompt and definitive to avoid extension into the danger space and risk of thoracic extension. In children that do not appear toxic, retropharyngeal abscesses may be managed with IV antibiotics and close observation for 24–48 h; with improvement, surgery can usually be avoided. However, most adults are with significant retropharyngeal abscesses are treated surgically. In some cases, retropharyngeal infections are associated with cervical spine hardware placed by the neurosurgeons or orthopedic surgeons. In these cases, it is important to determine if there is a pharyngeal or esophageal leak that has resulted in contamination of the hardware; any approach to treatment will require a plan to repair the leak. Preoperative evaluation usually includes a contrasted swallow study. Regardless of the presence of a leak, the contaminated cervical hardware must be removed to adequately treat the infection.

Further Reading

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