Imaging Approaches & Indications

Neither CT nor MR is a perfect modality for imaging the extracranial H&N. MR is most useful in the suprahyoid neck (SHN) because it is less affected by oral cavity dental amalgam artifact. The SHN tissue is less affected by motion compared with the infrahyoid neck (IHN); therefore, the MR image quality is not degraded by movement seen in the IHN. Axial and coronal T1 fat-saturated enhanced MR is superior to CECT in defining soft tissue extent of tumor, perineural tumor spread, and dural/intracranial spread. When MR is combined with CT of the facial bones and skull base, a clinician can obtain precise mapping of SHN lesions.

CECT is the modality of choice when IHN and mediastinum are imaged. Swallowing, coughing, and breathing makes this area a "moving target" for the imager. MR image quality is often degraded as a result. Multislice CT with multiplanar reformations now permits exquisite images of the IHN unaffected by movement.

High-resolution ultrasound also has a role. Superficial lesions, thyroid disease, pediatric neck lesions, and nodal evaluation with biopsy are often best done by ultrasonography.

Many indications exist for imaging the extracranial H&N. Exploratory imaging, tumor staging, and abscess search comprise 3 common reasons imaging is ordered in this area. Exploratory imaging, an imaging search for any lesion that may be causing the patient’s symptoms, is best completed with CECT from skull base to the clavicles. Squamous cell carcinoma (SCCa) staging is best started with CECT from skull base to the clavicles.

Imaging Anatomy

In discussing the extracranial H&N soft tissues, a few definitions are needed. The SHN is defined as deep facial spaces above the hyoid bone, including parapharyngeal space (PPS), pharyngeal mucosal space (PMS), masticator space (MS), parotid space (PS), carotid space (CS), retropharyngeal space (RPS), danger space (DS), and perivertebral (PVS) space. The IHN soft tissue spaces are predominantly below the hyoid bone with some continuing inferiorly into the mediastinum or superiorly into the SHN, including the visceral space (VS), posterior cervical space (PCS), CS, RPS, and PVS.

Important SHN space anatomic relationships include their interactions with the skull base, oral cavity, and infrahyoid neck. When one thinks about the SHN spaces and their relationships with the skull base, perhaps the most important consideration is to examine each space alone to see what critical structures (cranial nerves, arteries, veins) are at the point of contact between the space and the skull base. Space by space, the skull base interactions above and IHN extension below are apparent.

• PPS has bland triangular skull base abutment without critical foramen involved; it empties inferiorly into submandibular space (SMS)
• PMS touches posterior basiphoiden and anterior basiocciput, including foramen lacerum; PMS includes nasopharyngeal, oropharyngeal, and hypopharyngeal mucosal surfaces
• MS superior skull base interaction includes zygomatic arch, condylar fossa, skull base, including foramen ovale (CVN3), and foramen spinosum (middle meningeal artery); MS ends at inferior surface of body of mandible
• PS abuts floor of external auditory canal, mastoid tip, including stylomastoid foramen (CVN7); parotid tail extends inferiorly to posterior SMS
• CS meets jugular foramen (CVN1-X) floor, hypoglossal canal (CVN11), and petrous internal carotid artery canal; CS can be followed inferiorly to aortic arch; also called poststyloid parapharyngeal space
• RPS contacts skull base along lower clivus without involvement of critical structures; it continues inferiorly to empty into DS at T3 level
• PVS touches low clivus, encircles occipital condyles and foramen magnum; PVS continues inferiorly to level into thorax

In addition to skull base interactions, the relationships of the SHN spaces to the fat-filled PPSs are key to analyzing SHN masses. The PPSs are a pair of fat-filled spaces in the lateral SHN surrounded by the PMS, MS, PS, CS, and RPS. When a mass enlarges in one of these spaces, it displaces the PPS fat. Larger masses define their space of origin based on this displacement pattern.

• Medial PMS mass displaces PPS laterally
• More anterior MS mass displaces PPS posteriorly
• Lateral PS mass displaces PPS medially
• Posterolateral CS mass displaces stylloid process and PPS anteriorly
• More posteromedial lateral RPS nodal mass displaces PPS anterolaterally

The IHN space anatomic relationships are defined by their superior and inferior projections. The VS has no SHN component, instead projecting only inferiorly into the superior mediastinum. The PCS extends superiorly to the mastoid tip and ends inferiorly at the clavicle. It is predominantly an IHN space, however. The CS begins at the floor of jugular foramen and carotid canal and extends inferiorly to the aortic arch. The RPS begins at the ventral clivus superiorly and traverses SHN-IHN to T3 level. The DS is immediately posterior to the RPS but continues beyond T3 level into mediastinum. For imaging purposes, RPS and DS can be considered a single entity. The PVS can be defined from skull base above to clavicle below. The PVS is divided by fascial slip into prevertebral and paraspinous components.

Understanding the deep cervical fascia (DCF) of the neck can be challenging. However, it is these fasciae that define the very spaces we use to subdivide neck diseases and construct space-specific DDx lists. It is imperative that a clear understanding of these fasciae be grasped by any clinician caring for patients with disease in this area.

Many nomenclatures have been used to describe the neck fascia. The following is a practical distillate meant to simplify...
this challenging subject. There are 3 main DCF in the neck. The same names are used in the SHN and IHN. The superficial layer (SL-DCF), the middle layer (ML-DCF), and deep layer of DCF (DL-DCF) are the 3 important fascia in the neck. In the SHN, the SL-DCF circumscribes MS and PS and contributes to the carotid sheath. In the IHN, it “invests” neck by surrounding the infrahyoid strap, sternocleidomastoid, and trapezius muscles, which are derived from the same embryologic origin. It also contributes to the carotid sheath of the CS in the IHN.

The ML-DCF in the SHN defines the deep margin of the PMS. It contributes to carotid sheath in both the SHN and IHN. In the IHN, it also circumscribes the VS.

In both the SHN and IHN, the DL-DCF surrounds PVS. A slip of DL-DCF dives medially to the transverse process, dividing PVS into prevertebral and paraspinal components. Another slip of DL-DCF, the alar fascia, provides the lateral wall to RPS and DS, as well as the posterior wall to RPS, separating RPS from DS. DL-DCF contributes to carotid sheath, like the SL and ML-DCF.

The internal structures of the spaces of the neck are for the most part responsible for the diseases there. Let us begin by defining the critical contents of the SHN spaces.

- **PPS** contains fat with rare minor salivary glands
- **PMS** contains mucosa, lymphatic ring, and minor salivary glands; in nasopharyngeal mucosal space, opening of eustachian tube, torus tubarius, adenoids, superior constrictor, and levator palatini muscles can be seen; oropharyngeal mucosal space contains anterior and posterior tonsillar pillars, palatine, and lingual tonsils
- **MS** includes posterior mandibular body and ramus, TMJ, CVN3, masseter, medial and lateral pterygoid and temporalis muscles, and pterygoid venous plexus
- **PS** contains parotid, extracranial CNVII, nodes, retromandibular vein, and external carotid artery
- **CS** contains CNIX-XII, internal jugular vein, and internal carotid artery
- **RPS** has fat and medial and lateral RPS nodes inside
- **Prevertebral PVS** contains vertebral body, veins and arteries, and prevertebral muscles (longus colli and capitis); in paraspinal PVS resides posterior elements of vertebra and paraspinal muscles

The critical contents of IHN spaces are defined next.

- VS contains thyroid and parathyroid glands, trachea, esophagus, recurrent laryngeal nerves, and pretracheal and paratracheal nodes
- PCS has fat, CNXI, and level V nodes inside
- CS houses common carotid artery, internal jugular vein, and CNX
- **IHN RPS** has no nodes and contains only fat
- Prevertebral PVS has brachial plexus and phrenic nerve, vertebral body, veins, arteries, and prevertebral and scalene muscles within; paraspinal PVS contains only posterior vertebral elements and paraspinal muscles

### Approaches to Imaging Issues in SHN and IHN

It is crucial that the clinician has a method of analysis when a mass is found in the neck. In the SHN, mass evaluation methodology begins with defining mass space of origin (PMS, MS, PS, CS, lateral RPS). When small, this is simple, as the mass is seen within the confines of one space. In larger masses, ask, "How does the mass displace the PPS?" Next, utilize a space-specific DDx list. Match the imaging findings to the diagnoses within this list to narrow your differential.

With IHN masses, a similar evaluation methodology can be employed. First, determine what space the mass originates in (VS, CS, PCS). Then, review space-specific DDx list. Match radiologic findings of your case to this DDx list. The clinical findings will guide a clinician’s differential.

Lesions of posterior midline spaces (RPS and PVS) of the neck need different image evaluation. When a lesion is defined here, 1st ask, "How does mass displace prevertebral muscles (PVM)?" In the case of an RPS mass, PVMs are flattened posteriorly or invaded from anterior to posterior. Contrast this imaging appearance to that of the PVS mass in which the PVMs are lifted anteriorly or invaded from posterior to anterior. Since most PVS lesions arise from vertebral body, vertebral body destruction and epidural disease will be linked.

The DL-DCF "forces" PVS disease into the epidural space.

### Selected References


**Common Benign and Malignant Tumors in Spaces of Neck**

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SCCa = squamous cell carcinoma; NHL = non-Hodgkin lymphoma.
Suprahyoid and Infrahyoid Neck Overview

(Top) Axial graphic depicts the spaces of the suprahyoid neck. Surrounding the paired fat-filled parapharyngeal spaces (PPS) are the 4 critical paired spaces of this region, the pharyngeal mucosal (PMS), masticator (MS), parotid (PS), and carotid spaces (CS). Retropharyngeal (RPS) and perivertebral spaces (PVS) are the midline nonpaired spaces. A PMS mass pushes the PPS laterally, an MS mass pushes the PPS posteriorly, a PS mass pushes the PPS medially, and a CS mass pushes the PPS anteriorly. Lateral RPS mass pushes PPS anteriorly without lifting styloid process. The superficial (yellow line), middle (pink line), and deep (turquoise line) layers of deep cervical fascia outline the spaces.

(Bottom) Axial CECT at the level of the nasopharyngeal suprahyoid neck shows the 4 key spaces surrounding the PPS: The PMS, MS, PS, and CS. Notice the retropharyngeal fat stripe is not seen in the high nasopharynx between the prevertebral muscles and the pharyngeal mucosal surface.
Axial graphic shows the suprahyoid neck spaces at the level of the oropharynx. The superficial (yellow line), middle (pink line), and deep (turquoise line) layers of deep cervical fascia outline the suprahyoid neck spaces. Notice the lateral borders of the RPS and danger spaces are called the alar fascia, which represents a slip of the deep layer of deep cervical fascia. The CS has a tricolor fascial representation for the carotid sheath. This is because all 3 layers of deep cervical fascia contribute to the carotid sheath. In this image, through the low oropharynx, the PMS and the PVS have been outlined. The space between them is the RPS. The alar fascia that makes up the lateral borders of the RPS is not shown.
Suprahyoid and Infrahyoid Neck Overview

(Top) Axial graphic depicts the fascia and spaces of the infrahyoid neck. The 3 layers of deep cervical fascia are present in the suprahyoid and infrahyoid neck. The carotid sheath is made up of all 3 layers of deep cervical fascia (tricolor line around CS). Notice the deep layer (turquoise line) completely circles the PVS, diving in laterally to divide it into prevertebral and paraspinal components. The middle layer (pink line) circumscribes the visceral space, while the superficial layer (yellow line) "invests" the neck deep tissues.

(Bottom) In this axial CECT, the middle layer of deep cervical fascia is drawn to delineate the margins of the visceral space. The visceral space contains the high-density thyroid gland, the upper cervical esophagus, and the cricoid cartilage. The CS are lateral to the visceral space, while the RPS and PVS are posterior.
Suprahyoid and Infrahyoid Neck Overview

(Top) Coronal graphic shows suprahyoid neck spaces as they interact with the skull base. The MS has the largest area of abutment with the skull base, including CNV3. The PMS abuts the basisphenoid and foramen lacerum. The foramen lacerum is the cartilage-covered floor of the anteromedial petrous internal carotid artery canal. (Bottom) Sagittal graphic depicts longitudinal spatial relationships of the infrahyoid neck. Anteriorly, the visceral space is seen surrounded by middle layer of deep cervical fascia (pink line). Just anterior to the vertebral column, the RPS and danger space run inferiorly toward the mediastinum. Notice the fascial “trap door” found at the approximate level of T3 vertebral body that serves as a conduit from the RPS to the danger space. RPS infection or tumor may access the mediastinum via this route of spread.