Magnetic Resonance Imaging of the Oral Cavity and Oropharynx

Jerrin Varghese, MD, and Claudia Kirsch, MD

Abstract: Understanding oral cavity and oropharyngeal anatomy is important to identify various pathologies that may afflict them. This article reviews normal magnetic resonance imaging anatomy of these vital spaces and structures, with special attention to the complex musculature, mucosal surfaces, relevant osseous structures, salivary glands, and nerves. Anatomic awareness of these spaces and critical potential pathways for perineural tumoral spread are important to recognize to improve diagnostic evaluation and treatment.

Key Words: magnetic resonance imaging, oral cancer, oral cavity, oropharyngeal cancer, oropharynx, perineural spread, tongue

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The oral cavity's functions include food ingestion, mastication, phonation, and an alternative to the nasal cavity as a passageway for air. The tongue, teeth, and palate are components of the oral cavity contributing to these functions. The oropharynx is immediately posterior to the oral cavity and functions as a common passageway for food and air. One of its most important tasks is to protect the airway during swallowing, achieved by a complex coordination of muscular contractions. Imaging of the oral cavity and oropharynx is important in a wide variety of clinical settings and critically most often occurs during evaluation of an infectious or neoplastic process. Imaging can be performed utilizing computed tomography (CT) or magnetic resonance imaging (MRI). CT is a fast and relatively accessible modality especially advantageous when evaluating for pathology involving osseous structures of the oral cavity, including the teeth, mandible, and hard palate. CT can be, however, limited in soft tissue evaluation, especially when there is streak artifact from dental hardware. Radiation exposure to the patient is also a concern, especially in the pediatric population or in patients undergoing serial examinations. Therefore, MRI is a robust alternative imaging modality for the oral cavity and oropharynx due to its superior soft tissue resolution and lack of ionizing radiation. This is especially useful in evaluating oral cancers, the large majority of which are squamous cell carcinomas.[1]

Imaging protocols can be tailored toward certain anatomic areas of interest or for specific pathologies. Postcontrast MRI is extremely helpful in identifying otherwise difficult to visualize lesions, especially involving the mucosa. Although these types of lesions are more easily seen during physical examination, their infiltrative components are more easily identified by MRI and drive management and treatment protocols for the patient. Familiarization of the normal appearance of the oral cavity and oropharynx on MRI is critical to recognize and describe these types of pathology. This article reviews the oral cavity and oropharyngeal anatomy and describe the expected appearance of these structures on routine MRI sequences.

From the Neuroradiology Division, Northwell Health, Glen Oaks, NY.
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Address correspondence to Jerrin Varghese, MD, Neuroradiology Division, Northwell Health, 270-05 76th Ave, Glen Oaks, NY 11004 (e-mail: Jvarghese16@northwell.edu).
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MRI PROTOCOL

At our institution, MRI is performed with a neck coil with 3 to 4 mm slices and a 320 × 320 matrix. Imaging field of view is obtained from the skull base to the sternal notch. Axial and coronal T1-weighted images, axial and coronal fast spin echo T2-weighted images with fat saturation, axial short tau inversion recovery (STIR), and axial and coronal spin echo T1-weighted images postcontrast with fat saturation are obtained. Contrast material used is gadobutrol (Gadavist, Bayer AG, Leverkusen, Germany).

Precontrast nonsaturated T1 images are critical for assessing the normal muscular anatomy and fat planes, which can be obliterated in the setting of invasive tumor or infection. T2 STIR images are most useful in identifying areas of abnormal edema, especially helpful in the setting of infection. A standard protocol for imaging the oral cavity will always include T1 pre- and postcontrast and T2 and T2-STIR sequences in multiple planes and appropriate field of view.

ORAL CAVITY ANATOMY

The oral cavity begins at the vermilion border of the lips where the keratinized squamous cell epithelium meets the nonkeratinized squamous cell epithelium.[2] It ends at the level of the circumvallate papillae of the tongue and anterior tonsillar pillars. On MRI, the circumvallate papillae are not easily seen and therefore the hard/soft palate junction is used as a rough approximation of this posterior border (Fig. 1). The roof of the oral cavity consists of the palate and its floor is formed by the mylohyoid muscle. The lateral walls are formed by the cheeks, which contain the buccinator muscles.

Vestibule/Buccal Space

Deep to the lips are the orbicularis oris muscles, a group of muscles which function in lip movement essential for opening and closing the oral cavity as well as for facial expression (Fig. 2). Within the walls of the lateral mouth and deep to the buccal mucosa are the bilateral buccinator muscles, which extend from the angle of the mouth to the pterygomandibular raphe, and function to contract the cheeks.[2] This is important for control of food boluses during chewing and other functions including the playing of woodwind and brass instruments.

The inner lip and cheek surfaces are separated from the teeth by a potential space called the vestibule, which is lined by buccal mucosa peripherally and gingival mucosa along the maxillary and mandibular alveolar processes (Fig. 3). The gingival and buccal mucosa meet at the gingivobuccal sulcus.[2] On most routine MRI examinations, this space is often collapsed, potentially obscuring mucosal lesions. However, a "puffed cheek" technique may be used during imaging to distend this space with air and allow for better mucosal evaluation.[3,4] This technique has been described for CT imaging, but not often used in MRI due to limitations from susceptibility artifact from the additional air.[5]

The buccal space is a fat-containing space between the buccinator muscles and the superficial fascial layer or platysma muscle. It is deep to the subcutaneous fat of the face. Through this space runs the parotid duct, also known as Stensen duct, which then pierces the buccinator muscle before draining into the oral vestibule near the maxillary second molar tooth (Fig. 4). The buccal space can become

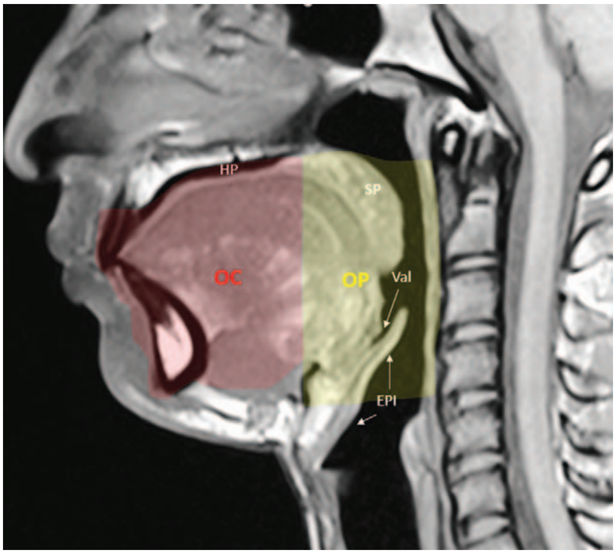

FIGURE 1. Sagittal T1 noncontrast image through the midline of the oral cavity and oropharynx. EPI indicates epiglottis; HP, hard palate; OC, oral cavity; OP, oropharynx; SP, soft palate; Val, valleculae.

infiltrated, most often secondary to infection of dental origin or neoplasm, and should be carefully evaluated in these situations.

Posterior to the mandibular molar tooth is the retromolar trigone, the triangle-shaped area of mucosa covering the ascending mandibular ramus which is a potential site of origin for squamous

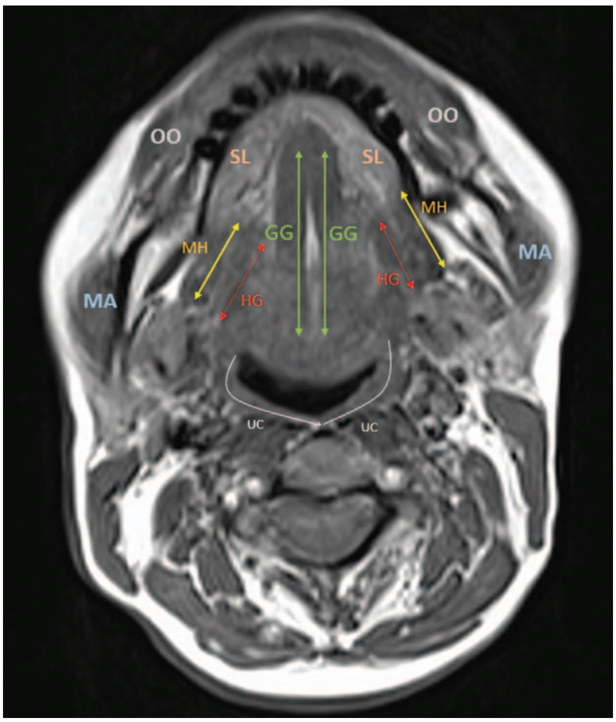

FIGURE 2. Axial noncontrast T1 image through the level of the mandibular bodies. GG indicates genioglossus; HG, hyoglossus; MA, masseter; MH, mylohyoid; OO, orbicularis oris; SL, sublingual gland; UC, upper pharyngeal constrictor.

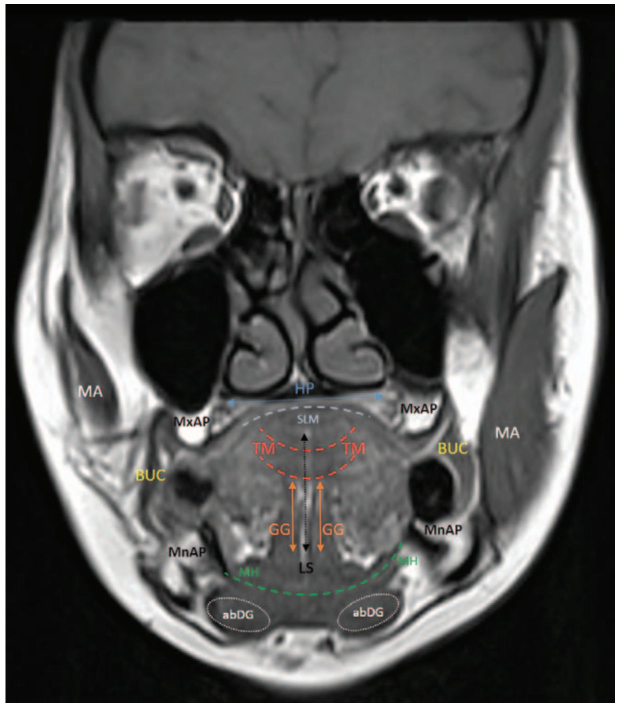

FIGURE 3. Coronal T1 image through the oral cavity. abDG indicates anterior body of the digastric muscle; BUC, buccinator; GG, genioglossus; HP, hard palate; ILM, inferior longitudinal muscle; LS, lingual septum; MA, masseter; MH, mylohyoid; MnAP, mandibular alveolar process; MxAP, maxillary alveolar process; SLM, superior longitudinal muscle; TM, transverse intrinsic muscle.

cell carcinoma (Fig. 4). On MRI, the trigone should appear relatively featureless, following the same signal characteristics of mucosa found elsewhere in the oral cavity and demonstrating symmetric enhancement. Just posterior to the retromolar trigone is the pterygomandibular raphe, a fibrous band along which carcinomas can travel superiorly into the infratemporal fossa or inferiorly into the submandibular space.[6] Although primary retromolar trigone lesions are relatively easily seen by direct inspection, tumor infiltration superiorly or inferiorly along this raphe is difficult to appreciate by direct visualization. Therefore, although the raphe itself is difficult to visualize on MRI, evaluation for tumor spread along the expected location of this structure is critical on imaging in patients with known retromolar trigone lesions to appropriate stage the tumor and guide management.

Tongue

The space bounded by the teeth and bordered posteriorly by the circumvallate papillae is considered the oral cavity "proper." It contains the tongue, which is made up of multiple intrinsic and extrinsic muscles, which can be well differentiated on T1-weighted images (Figs. 2, 3, 5). The lingual septum is a midline fibrous band that acts as an attachment site for many of these muscles. The genioglossus muscles are fan-shaped muscles arising from the mandibular symphysis with fibers spreading into the body of the tongue, best appreciated on sagittal images. The genioglossus is responsible for tongue protrusion and unilateral paralysis results in deviation of the tongue toward the affected side. The hyoglossus muscles are vertically oriented, originating from the hyoid bone and extending into the lateral aspects of the tongue body. These muscles

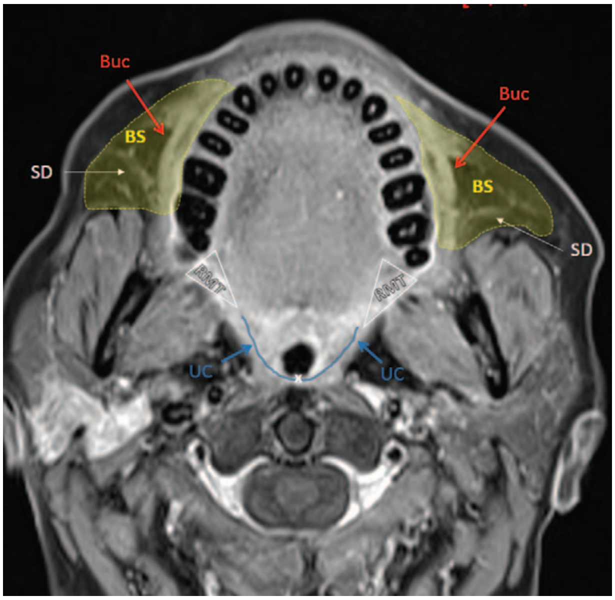

FIGURE 4. Axial postcontrast T1 image through the level of the mandibular teeth. BS indicates buccal space; Buc, buccinator; RMT, retromolar trigone; SD, Stenson duct; UC, upper pharyngeal constrictor; X, median pharyngeal raphe. Enhancing lesion in the right parotid was a pathology-proven pleomorphic adenoma.

are best seen on axial images, coursing just medial to the mylohyoid muscles bilaterally at the level of the mandible (Fig. 2). The styloglossus muscles originate from the styloid processes and insert into the body of the tongue laterally. They function to raise the tongue superiorly and posteriorly during swallowing. The superior and inferior longitudinal muscles are intrinsic muscles coursing anteroposteriorly through the tongue, allowing concave and convex curvatures of its dorsal surface (Fig. 5). Additional intrinsic muscles include the transverse and oblique muscles, seen best on MRI in patients with fatty infiltration/atrophy of the tongue.

Floor of Mouth

The floor of mouth is formed primarily by the bilateral mylohyoid muscles. The mylohyoid originates from a midline fibrous raphe, which extends from the mandibular symphysis to the hyoid body. Its insertion is broad, extending along the bilateral mylohyoid lines of the lingual cortex of the mandible (Figs. 2, 3).[2] The posterolateral edges of the mylohyoid have no attachment, and float freely. Of note, lesions that displace the mylohyoid inferiorly usually arise from the floor of mouth or tongue, whereas lesions that displace it superiorly arise from the submandibular space.[7]

Along the posterior border of the mylohyoid muscle are the bilateral submandibular glands, part of the major salivary glands, which are drained by the paired Wharton ducts (Fig. 6). The submandibular glands demonstrate relatively hypointense signal on T1-weighted images and relatively hyperintense signal on T2/STIR images. Its ducts pierce the inferior surface of the mylohyoid before draining into oral cavity below the tongue. Lesions arising from the floor of mouth or tongue root can obstruct these ducts, resulting in dilation that can be seen by MRI.[1] The sublingual glands are also major salivary glands located more anteriorly, adjacent to the inner surface of the mandibular bodies within the sublingual space.

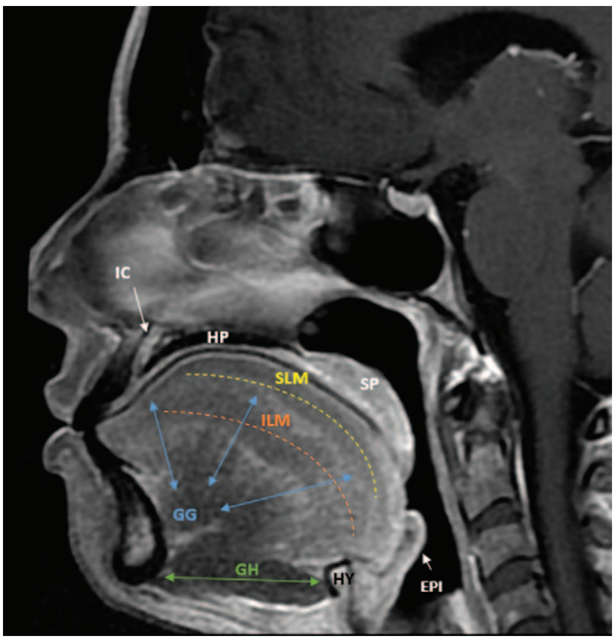

FIGURE 5. Sagittal postcontrast T1 image at midline. EPI indicates epiglottis; GG, genioglossus; GH, geniohyoid; HP, hard palate; HY, hyoid; IC, incisive canal; ILM, inferior longitudinal muscle; LS, lingual septum; MA, masseter; MH, mylohyoid; MnAP, mandibular alveolar process; MxAP, maxillary alveolar process; SLM, superior longitudinal muscle; SP, soft palate.

FIGURE 6. Axial STIR image through the floor of mouth. IAN indicates inferior alveolar nerve within the mandibular canal; SLG, sublingual gland and ducts; SMG, submandibular gland; WD, Wharton's duct.

This space is deep to the mucosa of the floor of mouth and superior to the mylohyoid muscle. The sublingual glands made up of a group of individual glands and drain via short ducts into the oral cavity. The sublingual glands are best seen on STIR or postcontrast T1 images due to their fluid content and normal enhancement of salivary gland parenchyma (Fig. 7).

The lateral borders of the floor of mouth are formed by the inner, or lingual cortex of the mandible. While cortex is usually better evaluated by CT, MRI is superior in evaluation of the marrow.[8] The adjacent marrow is important to evaluate to exclude tumor involvement when assessing oral cavity tumors including those arising from the floor of mouth. Bone involvement significantly upstages oral cancers and portends a worse prognosis and is therefore important to identify.[9] MRI is also superior in assessment of perineural spread from the oral cavity, which in the case of floor of mouth lesions usually involves spread into the mandibular canal containing the inferior alveolar nerve.[10] This canal begins at the inner cortex of the mandibular angle, where the nerve is usually targeted for inferior alveolar nerve blocks, and runs within the inferior aspect of the mandibular body (Figs. 6, 7). It ends at the mental foramen, an opening in the anterior third segment of the buccal or outer cortex of the mandible.

Palate

The palate functions as the roof of the mouth and is separated into the hard and soft palate. The hard palate is formed by the maxillary bone anteriorly and the paired palatal bones posteriorly. These flat bones are covered by mucosa continuous with the remainder of the oral cavity. The incisive foramen and its canal are located just posterior to the central incisors at the midline and oriented vertically (Fig. 5). It contains the nasopalatine neurovascular bundle.[11] At the junction of the maxillary and palatine portions of the hard palate are the paired greater and lesser palatine foramina with their associated greater and lesser palatine canals, respectively. These are potential pathways for perineural spread of palatine neoplasms, which make their careful evaluation important on MRI.[9] Laterally, the palate is framed by the maxillary alveolar processes, which contain the maxillary teeth. These osseous structures are also important to carefully evaluate in the setting of nearby palatine mucosal tumors, similar to the mandible with respect to the floor of mouth.

The soft palate, or velum, is directly posterior to the hard palate and lacks a bony scaffolding. Instead, it contains a midline aponeurosis, which serves as attachment sites for the tensor veli palatini and the levator veli palatini. Both muscles also arise from the petrous bone, but the tensor veli palatini has a tendon which wraps around the pterygoid hamulus laterally before inserting into the soft palate. The tensor veli palatini functions to tense the palate.[12] This assists in raising the soft palate, which results in the blocking off of the nasopharynx during swallowing. These muscles also thought to open the orifice to the eustachian tube, allowing for drainage and pressure equalization of the middle ear.[13] The uvula extends from the dorsal midline edge of the soft palate and dangles inferiorly. It should be noted that most anatomists consider the soft palate a part of the oropharynx.[2]

FIGURE 7. Coronal T2-STIR image through the midoral cavity. abDG indicates anterior body of the digastric muscle; GG, genioglossus; IAN, inferior alveolar nerve; MnAP, mandibular alveolar process; MxAP, maxillary alveolar process; SLG, sublingual glands.

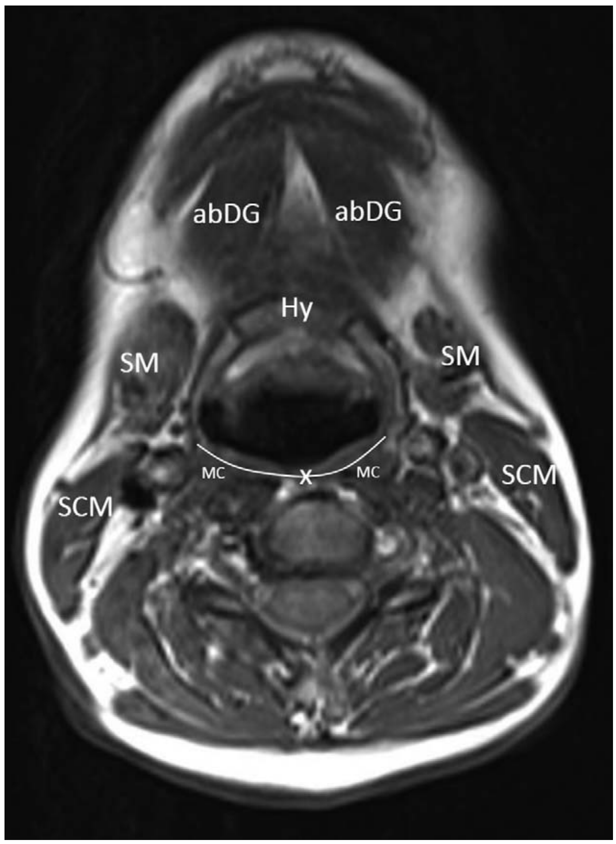

FIGURE 8. Axial noncontrast T1 image through the level of the hyoid and mandibular symphysis. abDG indicates anterior body of the digastric muscle; Hy, hyoid bone; MC, middle pharyngeal constrictor; SCM, sternocleidomastoid; SM, submandibular gland; X, median pharyngeal raphe.

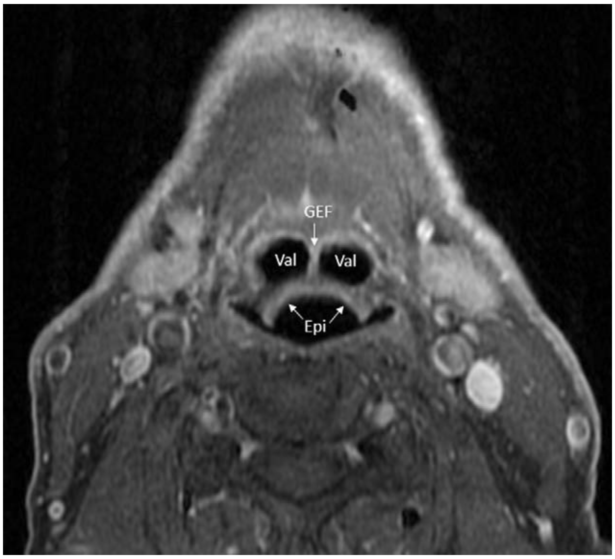

FIGURE 9. Axial postcontrast T1 image through the lower oropharynx. Epi indicates epiglottis; GEF, glossoepiglottic fold; Val, valleculae.

OROPHARYNX

The oropharynx is located directly posterior to the oral cavity. It is anteriorly bounded by the hard and soft palate junction, superiorly by an imaginary line extending posteriorly from the palate, and inferiorly at the level of the hyoid bone (Fig. 1). Its contents include the soft palate (which is discussed above in conjunction with the hard palate), posterior third of the tongue or tongue base, palatine and lingual tonsils, and epiglottis. Superior to the oropharynx is the nasopharynx and inferior to it is the hypopharynx and larynx.

The oropharyngeal mucosa is continuous with that of the oral cavity. Deep to this mucosa along the lateral and posterior aspects of the oropharynx are the superior and middle pharyngeal constrictor muscles (the inferior pharyngeal constrictor is part of the hypopharynx. The paired thin and broad superior pharyngeal constrictor muscles arise from the pterygomandibular raphe bilaterally, extend posteriorly around the oropharynx, and insert into the median raphe, a dorsal midline fibrous band (Figs. 4, 8).[2] The middle pharyngeal constrictor largely arises from the hyoid bones and also extend around the oropharynx to insert into the median raphe, with some overlap with the superior constrictor muscle (Fig. 6).[2] Two paired mucosa-covered arches are found along the lateral aspects of the upper oropharynx. The anterior arches are formed by the palatoglossus muscles and the posterior arches are formed by the palatopharyngeus muscles.[2] The tonsillar fossa is located between these arches and contains the palatine tonsils, a common site for oropharyngeal carcinoma. These tonsils can vary in size based on age, usually peaking in size in the adolescent years and then progressively involuting with age.[2] The lingual tonsils, on the contrary, are located along the tongue base and can extend inferiorly toward the valleculae. The valleculae are paired recesses divided at the midline by the glossoepiglottic fold, which extends from the tongue base anteriorly to the epiglottis posteriorly (Fig. 9). The lingual tonsils may encroach the valleculae partially, but if they contact the vallecular floor, suspicion for tumor should be raised.[2]

The epiglottis is a leaf-shaped cartilaginous structure covered by mucosa that acts as a flap opening to the larynx inferior to it (Fig. 1). It features a wide upper margin, which is suspended freely in the pharyngeal lumen. It tapers inferoanteriorly to a point called the petiole, which is anchored onto the thyroid cartilage.[14] The epiglottis is best imaged on sagittal imaging, where its caliber and position can be best evaluated.

CONCLUSIONS

Familiarity with the MRI anatomy of the oral cavity and oropharynx is essential in the evaluation of patients presenting with all varieties of head and neck pathologies, most commonly neoplasm or infection. A thorough imaging evaluation can only be achieved once one appreciates the normal appearance of the numerous muscle groups, mucosal surfaces, bones, and neurovascular channels that make up these structures.

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