Imaging review of the normal anatomy of the oral cavity

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Learning objectives

The purpose of this exhibit is to review the normal anatomy of the oral cavity and its imaging appearance on both computed tomography and magnetic resonance imaging. Special attention will be placed on radiological landmarks important for identification and staging of squamous cell carcinoma of the oral cavity.

Background

From an imaging standpoint, the oral cavity is a complex region given the combination of different organ systems, including the digestive, musculoskeletal, vascular, and nervous systems. In order to adequately evaluate this region, a knowledge of the radiological anatomy and important landmarks is vital, since clinicians frequently depend upon the radiological interpretation in order to assess spread of disease and staging of cancers in this region. Failure to adequately evaluate key areas may lead to incomplete assessment, disease progression, and/or failure of treatment.

Findings and procedure details

Normal anatomy: Osseous structures

Maxillae:

- The alveolar and palatine processes make the roof of the oral cavity.
- The anterior two-thirds of the hard palate are composed of the two palatine processes that project from the medial surface of each maxilla.
- Two incisive canals behind the incisor teeth on each side of the maxilla allow passage of the greater palatine vessels and the nasopalatine nerves.

Palatine bones:

- A pair of 'L'-shaped bones that contribute to the roof of the oral cavity.
- Divided into two regions: the horizontal plate and the pyramidal process.
- Horizontal plate: projects medially and is joined by sutures to its partner in the midline, forming the nasal spine.
- Pyramidal process: projects posteriorly between the inferior ends of the medial and lateral plates of the pterygoid process of the sphenoid bone.
Sphenoid bone:

- From the lateral aspect of the body descend the pterygoid processes.
- Each process has a vertically-oriented medial plate and a lateral plate projecting from its posterior aspect.
- The pyramidal process of the palatine bone occupies the space between the two plates.

Pterygoid hamulus:

- Hook-shaped structure that projects posterolaterally from the inferior margin of the medial plate of the pterygoid process.
- Attachment site for the upper end of the pterygomandibular raphe.
- The scaphoid fossa lies at the root of the medial plate of the pterygoid process and serves as attachment for the tensor veli palatini muscle.
- The sphenoid spines lie posteromedial to the foramen spinosum.
- The medial aspect of the spine serves as the attachment site for the lateral part of the tensor veli palatini muscle.

Mandible:

- The floor of the oral cavity is made up by the mandibular bone.
- The alveolar arch of the mandible anchors the lower teeth.
- The mylohyoid line lies inferomedial to the mental spines and divides the sublingual fossa from the submandibular fossa.
- The lingual nerve courses in a groove between the last molar tooth and the mylohyoid line.
- Posterior to the last molar lies the retromolar trigone.
- The inferior alveolar nerve and artery enter the oral cavity through the mandibular foramen and exit through the mental foramen located in the anterior surface of the mandible, where they become the mental nerve and artery.
Fig. 1: Diagram demonstrating the mandible anatomy

References: Radiology, University of Puerto Rico Medical Sciences Campus - San Juan/US

Hyoid bone

- The hyoid bone connects the floor of the oral cavity with the pharynx and the larynx.

Normal anatomy: Oral mucosal surfaces

The oral mucosal surface may be divided into eight areas:

- Mucosal lip: Begins at the vermillion border junction with skin (9).
- Upper alveolar ridge mucosal surface: extends from the upper gingival buccal gutter to the junction of the hard palate and overlies the alveolar process of the maxilla (9).
- Lower alveolar ridge mucosal surface: extends from the buccal gutter to the mucosa of the floor of the mouth and overlies the alveolar process of the mandible (9).
• Retromolar trigone mucosal surface: extends from the posterior surface of the last molar tooth to its apex superiorly and overlies the ascending ramus of the mandible (9).
• Buccal mucosa: composed by all membranes lining the inner cheeks and lips and extends from the line of contact of opposing lips to the pterygomandibular raphe (9).
• Floor of mouth mucosal surface: extends from the inner lower alveolar ridge to the undersurface of the tongue and overlies the mylohyoid and hyoglossus muscles. Divided by the frenulum. Contains the ostia of the submandibular and sublingual salivary glands (9).
• Hard palate mucosal surface: a semilunar area that extends from the inner superior alveolar ridge to the posterior palatine bone (9).
• Oral tongue mucosal surface: extends anteriorly from the circumvallate papillae to the undersurface of the tongue. Includes the tongue tip, lateral borders, dorsum and undersurface (9).
• There are no fascia delineating the oral mucosal surface (9).

Fig. 9: Diagram demonstrating the oral mucosa.

References: Radiology, University of Puerto Rico Medical Sciences Campus - San Juan/US
**Normal anatomy: Sublingual space Fig. 6 on page 14**

The sublingual and submandibular spaces are divided by the mylohyoid muscle anteriorly. Since their posterior surface has no margins present, it is a potential area for lesions to spread freely.

Lateral to the hyoglossus muscles lie the:

- Submandibular duct
- Hypoglossal nerve
- Lingual nerve

Medial to the hyoglossus muscle lie the:

- Lingual artery and vein
- Important landmark for patients with carcinoma of the floor of the mouth.

**Normal anatomy: Submandibular space Fig. 6 on page 14**

- A horseshoe-shaped area that lies above the hyoid bone, deep to the platysma muscle and superficial to the mylohyoid sling.
- Communicates posteriorly with the sublingual space, divided by the mylohyoid muscle.
- Continues inferiorly into the infrahyoid neck as the anterior cervical space.
- The submandibular space contains the submandibular gland, the facial vein and artery, the caudal loop of the hypoglossal nerve, and the anterior belly of the digastric muscles (9).
- The tail of the parotid gland may extend into the posterior area of the submandibular space.

**Normal anatomy: Tongue**

Oral tongue

- Anterior # of the tongue, sits centrally within the oral cavity.
- Divided into the tip, lateral borders, the dorsum and the nonvillous undersurface.
- Innervated by the lingual branch of CN VII.

Root of Tongue

- Posterior # of the tongue, located in the oropharynx.
- Ends anteriorly at the mandibular symphysis, inferiorly at the mylohyoid sling, and superiorly at the intrinsic tongue muscles.
• Includes the lingual septum, inferior portion of genioglossus and geniohyoid muscles.
• Innervated by CN IX.

Vasculature of tongue

• The lingual artery and lingual vein course parallel to each other beneath the hyoglossus muscle. The lingual artery ascends perpendicularly and becomes the deep lingual artery.

Fig. 2: Diagram demonstrating the tongue muscles.

References: Radiology, University of Puerto Rico Medical Sciences Campus - San Juan/US
<table>
<thead>
<tr>
<th>Extrinsic Tongue muscles</th>
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<tbody>
<tr>
<td><strong>Origin</strong></td>
</tr>
<tr>
<td>Genioglossus</td>
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<tr>
<td>Hyoglossus</td>
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<tr>
<td>Styliglossus</td>
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<tr>
<td>Palatoglossus</td>
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</table>

**Fig. 3:** Extrinsic tongue muscles

**References:** Radiology, University of Puerto Rico Medical Sciences Campus - San Juan/US

**Spread of disease:**

SCC of the oral cavity usually spreads via three different routes and vary according to anatomic subsite and T category.

1. First route is through direct extension to the mucosa, muscles and bones.
   - Osseous invasion, most commonly to mandible and maxilla, is classified as a T4 lesion and is better assessed using CT.
   - Marrow invasion is better assessed using MRI (6).

2. Second route is via the lymphatics, usually involving lymph nodes at level I and II of the neck.
   - Highest frequency of regional disease is seen in the retromolar trigone, floor of the mouth and oral tongue.
   - SCC in the lip, buccal mucosa, and hard palate are less likely to manifest with lymphadenopathy (7).
   - The hallmark imaging features of pathologic lymphadenopathy are nodal size > 10mm and the presence of central necrosis, identified as a central region of hypoattenuation with a rind of enhancing tissue on CT.

3. Third route is via vascular and perineural invasion.
• Perineural invasion is thought to be characteristic of aggressive SCC.
• Detected by contrast-enhanced MRI showing nerve or foraminal enlargement and replacement of normal fat within the neural foramen.

**Important regions of spread of disease:**

**Glossomylohyoid gap**

• The glosso-mylohyoid gap lies between mylohyoid muscle and lateral extrinsic glossal muscles. It serves as a posterior communication and possible pathway for spread of disease between the sublingual and submandibular spaces. This gap also connects the spaces with the inferior parapharyngeal fatty space. The submandibular gland may extend up to the dorsal aspect of the mylohyoid muscle through this gap.

**Pterygomandibular raphe**

• The pterygomandibular raphe extends from the posterior mylohyoid line to the hamulus of the medial pterygoid plate. Provides access to the masticator space superolaterally and the floor of the mouth inferomedially. It serves as an origin point for the buccinator and superior pharyngeal constrictor muscles which makes it a potential route of spread of squamous cell carcinoma into the buccal space and oropharynx (3).

**Retromolar trigone:**

• The retromolar trigone is an area of mucosa stretching from the last mandibular molar, that attaches to the hamulus of the medial pterygoid process of the sphenoid bone. SCC can spread to muscle of mastication, mandibular ramus and mandibular branch of trigeminal nerve (5). Also, the alveolar nerve is at risk of invasion at its site of entry to the mandibular foramen (8). However, they show a strong predilection for lymphatic involvement. Early bone invasion may also be seen.

**Perineural spread:**

• Refers to tumor spread beyond the primary site by travelling along the perineural sheath or endoneurial plane (1). Perineural invasion is thought to be characteristic of aggressive SCC, for which its demonstration should prompt adjuvant treatment decisions and surgical management. It is important for radiologists to be aware that it needs to be detected by contrast-enhanced MR imaging showing nerve or foraminal enlargement and replacement of normal fat within the neural foramen (4). Coronal fat-suppressed post-gadolinium T1W MRI demonstrates perineural spread as increased enhancement. Involvement of the mandible raises awareness for perineural invasion, most commonly spreading from the retromolar trigone.
to the mandibular branch of the trigeminal nerve. Atrophy of the masticator muscles may be indicative of long-standing perineural spread (1).

**Squamous cell carcinoma**

**Overview:**

- Squamous cell carcinoma is the most common malignancy encountered in the oral cavity and oropharynx.
- It is associated with tobacco, alcohol use, and with HPV Type 16 most commonly.
- The most common site for SCC is the lip, arising from the vermilion border and spreading most commonly to the skin or orbicularis oris muscle via lymphatic route or along the buccal surface of the maxillary/mandibular alveolar ridge through osseous involvement.
- Also, the buccal mucosa is another site for SCC, most commonly occurring in the lateral walls. It usually spreads along the buccinator muscle submucosally to the retromolar trigone and pterygomandibular raphe.
- From the retromolar trigone, can spread to muscle of mastication, mandibular ramus and mandibular branch of trigeminal nerve.
- Involvement of the mandible raises awareness for perineural invasion, and involvement of the maxilla raises awareness for paranasal sinuses spread.
- Thus, for accurate staging of SCCs of the oral cavity, evaluation of these three routes of spread and their most common anatomic structures is mandatory.
- Due to proximity of the internal carotid artery to this structures, it should be evaluated as well.
- Imaging is essential to determine the extent of the lesion, depth of invasion and involvement of nodules.
- Even though distant metastasis is uncommon, the lung the most common site.

Different therapeutic strategies are assessed depending on tumor staging and primary site. Thus, it is imperative to classify every lesion using the AJCC TNM System taking in consideration their classification.

**NCCN Guidelines in Management for Cancer of the Oral Cavity: Fig. 13 on page 18**

- For stages I-II: resection of primary +/- neck dissection, or resection of primary +/- neck dissection, or radiation therapy
- Stage III = Resection of primary and ipsilateral, or bilateral neck dissection
- Stage IVa (moderately advanced local-regional disease) = combined chemo and radiation therapy
- Stage IVb (very advanced local-regional disease) = combined chemo and radiation therapy
• Stage IVc (distant metastatic disease) = palliative therapy

Images for this section:

**Fig. 1:** Diagram demonstrating the mandible anatomy

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**Fig. 2:** Diagram demonstrating the tongue muscles.

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### Extrinsic Tongue muscles

<table>
<thead>
<tr>
<th></th>
<th>Origin</th>
<th>Insertion</th>
<th>Innervation</th>
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</thead>
<tbody>
<tr>
<td>Genioglossus</td>
<td>Upper genial tubercle and inner symphysis menti</td>
<td>Body of hyoid; Tongue undersurface</td>
<td>CN XII</td>
</tr>
<tr>
<td>Hyoglossus</td>
<td>Body and greater cornu of hyoid bone</td>
<td>Lateral surface of tongue</td>
<td>CN XII</td>
</tr>
<tr>
<td>Styliglossus</td>
<td>Styloid process and stylomandibular ligament</td>
<td>Lateral tongue/ Merges with hyoglossus muscle</td>
<td>CN XII</td>
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<td>Palatoglossus</td>
<td>Undersurface of palatine aponeurosis</td>
<td>Dorsolateral tongue</td>
<td>CN X</td>
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**Fig. 3:** Extrinsic tongue muscles

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![Extrinsic tongue muscles](image)

**Fig. 4:** Diagram demonstrating the anatomy of the midline oral cavity

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Fig. 5: Sagittal T1 image showing the midline oral cavity.

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Fig. 6: Diagram demonstrating the relationship between the sublingual and submandibular space.

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Fig. 9: Diagram demonstrating the oral mucosa.

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Fig. 7: Coronal T2 image of the oral cavity demonstrating the mylohyoid muscle, which divides the sublingual from submandibular space.

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**Fig. 8:** Coronal T2 image demonstrating the sublingual space.

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**Fig. 10:** Axial T2 image shows the retromolar trigone, parapharyngeal space, and superior pharyngeal constrictor muscles.

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**Fig. 11:** Tongue SCC. Contrast-enhanced CT scan (A) axial, (B) sagittal, (C) coronal show a large infiltrative mass involving the oral surface of the tongue, extending into the left lateral intrinsic muscles, with superior extension, abutting, and likely infiltrating, the left genioglossus and geniohyod muscles. There is lateral extension into the left floor of mild and into the left submandibular space. The lesion is abutting the left mylohyoid muscle, and is extending into the left base of tongue.

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**Fig. 12:** Axial contrast enhanced CT images show a left base of tongue squamous cell carcinoma extending to the intrinsic muscles of the tongue (abutting the left neurovascular bundle) and sublingual region.

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<table>
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<th>Cancer Stage</th>
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<th>Category M (metastasis)</th>
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<td>Metastasis to distant sites (MC = Lungs)</td>
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**Fig. 13:** TNM classification for SCC of the oral cavity

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Conclusion

Squamous cell carcinoma is the most common malignant tumor of the oral cavity and oropharynx, accounting for more than 90% of malignancies of these areas. Knowledge of the normal anatomy and radiological landmarks of these areas is essential for identifying and staging disease. Adequate radiological assessment is vital for physician treatment and surgery planning.

Personal information

References