heavy smokers with high volumes of alcohol intake have a relative risk of more than 20 times that of individuals who do not use tobacco or alcohol.11,12

◆ Natural History and Clinical Presentation

Sixty to seventy percent of oral tongue cancers arise from the lateral surface of the middle third of the tongue (Fig. 11–3), and 30 to 40% originate from the ventrolateral or anterior undersurface.13 Carcinoma arising from the dorsum of the tongue is an uncommon but real entity that accounts for 3 to 5% of oral tongue cancers, and carcinoma can rarely originate from the dorsal midline.14,15

Early oral tongue cancers typically arise within regions of leukoplakia or erythroplakia and are frequently asymptomatic. Progressive growth eventually results in surface ulceration and muscular invasion, which cause pain and limitation of motion. Tumor extension can proceed into the floor of the mouth and lingual alveolar lining mucosa and gingiva with underlying mandibular involvement. Growth can also occur posteriorly into the base of tongue, glossotonsillar sulcus, and anterior tonsillar pillar region. Extensive submucosal muscular invasion can occur in the absence of overlying mucosal abnormalities. Significant impairment of mobility may result from invasion of the deep or extrinsic tongue muscles, which include the genioglossus, hyoglossus, palatoglossus, and styloglossus. Physical examination should include close inspection of the surrounding mucosal surface and palpation to determine the extent of muscular involvement.

Similarly, FOM cancers are often asymptomatic until submucosal invasion or ulceration occurs. Approximately 80% of FOM cancers arise in the anterior FOM, and extension onto the lingual gingiva occurs in 15% of lesions less than 4 cm in size.16,17 Contiguous involvement of the undersurface of the tongue progresses in an unhindered fashion, and involvement of the deep tongue musculature can develop with subsequent impairment in mobility. Once again, careful inspection and palpation are necessary to quantify the extent of tumor involvement. The presence of periosteal or mandibular invasion can be assessed by using bimanual palpation to determine the mobility of the lingual alveolar mucosa, but this examination technique is frequently difficult to perform in the presence of painful, bulky tumors (Fig. 11–4). Radiographic evaluation must be combined with clinical examination to accurately detect the presence of mandibular invasion in most cases.18 Mandibular invasion is reviewed in depth in Chapter 12.

Radiographic evaluation with computed tomography (CT) or magnetic resonance (MRI) provides important complementary information that impacts staging and therapy. Contrast-enhanced CT can be used to determine the extent of submucosal and muscular invasion, and bone algorithms are helpful in determining the presence of mandibular invasion. MRI detects perineural spread with greater sensitivity than CT, facilitates the detection of marrow replacement, and characterizes the extent and pattern of muscular invasion in greater detail than CT scan. The fibrous lingual septum, which vertically bisects the tongue, is seen as a hypodense midline structure on CT scan and has been referred to as the midline low-density plane.3 The largely fat-filled sublingual compartment of the submandibular space, or sublingual space, is also hypodense on CT and is termed the lateral low-density plane.3 Qualitative changes in these landmarks are useful for the assessment of tumor extension across the midline of the tongue and into the sublingual space, respectively. Radiographic imaging is also utilized to evaluate for regional nodal metastasis as an integral aspect of the staging workup.

Tumor staging for both sites corresponds to the criteria used for other oral cavity sites (see Chapter 7). Tongue and FOM lesions that invade through cortical bone, into the deep (extrinsic) tongue musculature (genioglossus, hyoglossus, palatoglossus, and styloglossus), or invade the skin of the face, are designated T4a lesions.1 Superficial mandibular bone erosion is not sufficient to apply the T4 designation.1 Internal carotid artery encasement resulting from contiguous tumor growth through the FOM into the neck is
considered a T4b lesion. Invasion of the masticator space, pterygoid plates, and skull base are unusual manifestations of cancer arising from these areas that would result in the T4b designation.1

At the time of presentation, the T-stage distribution for oral tongue cancer is as follows: T1, 15 to 38%; T2, 36 to 53%; T3, 22 to 26%; T4, 4%19,20. The clinical N-stage distribution is as follows: N0, 75%; N1, 16%; N2, 6%; N3, 3%.20 The clinical stage distribution is as follows: I, 37%; II, 28%; III, 24%; IV, 11%.20 Overall, approximately 45% of patients with oral tongue cancer are pathologically node-positive, and 38% of these patients have extracapsular spread.19

The T-stage distribution of patients with FOM cancer at initial presentation is as follows: T1, 30 to 33%; T2, 32 to 37%; T3, 11 to 19%; T4, 14 to 23%. The N stage on presentation has been reported to be as follows: N0, 59 to 62%; N1, 23 to 24%; N2, 6 to 13%; N3, 2 to 11%. The stage distribution is as follows: I, 27 to 30%, II, 21 to 22%; III, 17 to 26%; IV, 25 to 31%.21,22

Occult nodal metastases (ONM) in patients with either oral tongue or FOM cancer most commonly occur in lymph node levels I and II. The rate of ONM in patients with oral tongue cancer by lymph node level is as follows: I, 14%; II, 19%; III, 16%; IV, 3%; V, 0%.23 The frequency of ONM in patients with FOM cancer by lymph node level is as follows: I, 16%; II, 12%; III, 7%; IV, 2%; V, 0%.23 Level IB metastases predominantly involve the prevascular or retrovascular nodes.24,25 In clinically node-positive necks, the rate of occult nodal metastatic disease exceeds 30% in lymph node levels I through III for both oral tongue and FOM cancers.23 Level IV contains metastatic disease in 21% and 12% of oral tongue and FOM cancers, respectively. Level V metastatic disease typically occurs only in the presence of nodal disease at other levels in less than 10% of clinically positive necks.23 An increased risk of contralateral metastasis is associated with advanced T stage, poorly differentiated lesions, multiple ipsilateral nodal metastases, FOM carcinoma, and tumors that extend to within 1 cm of the midline.26,27

"Skip metastases," which are metastases to levels IIB, III, or IV in the absence of level I or IIA metastases, were noted Byers and colleagues28 in 16% of patients with oral tongue cancer. Other investigators have also documented the existence of skip metastases in patients with oral tongue cancer as well as oral cancer originating from other sites.29,30 Although it is possible that skip metastases are due to histopathologic sampling error during evaluation of the neck dissection specimen, their existence should be acknowledged until more conclusive data from prospective sentinel lymphadenectomy research that evaluates the patterns of nodal metastasis from squamous cell carcinoma are available. The need for level IV dissection in patients with a clinically negative neck is controversial. Investigators who have found a 7% rate of skip metastases in level IV are strong advocates of level IV dissection, whereas others have documented a 4% rate of ONM in the clinically node-negative neck, leading them to conclude that removal of level IV is unnecessary.28,31 Level IV dissection should be performed in the clinically positive neck, because the rate of level IV nodal disease in this case is 15%.23

Regional nodal metastases from oral tongue and FOM cancer have been associated with T stage, pattern of invasion, angiolymphatic invasion, perineural invasion, and degree of tumor differentiation.25,32–37 Tumor thickness and depth of invasion, however, appear to be the best predictors of nodal metastatic disease (Table 11–1).33,38–44 But attempts to define the tumor thickness or depth of invasion that requires treatment of the neck remain elusive. Two investigations documented regional metastatic rates of less than 20% when depth of tumor invasion was as great as 5 mm, whereas two other publications demonstrate metastatic rates of greater than 20%.

Table 11–1 Relationship Between Tumor Thickness* (TT) or Depth of Invasion† (DI) and Occult Nodal Metastasis (ONM) in Patients with Cancer of the Oral Tongue or Floor of Mouth

<table>
<thead>
<tr>
<th>First Author</th>
<th>Parameter Measured</th>
<th>Rate of ONM (%) when TT/DI is:</th>
<th>Shallower</th>
<th>Deeper</th>
</tr>
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<tr>
<td>Oral tongue</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spiro38</td>
<td>TT (mm)</td>
<td>2</td>
<td>21</td>
<td>45</td>
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<tr>
<td>Yuey9</td>
<td></td>
<td>3</td>
<td>8</td>
<td>44</td>
</tr>
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</tr>
<tr>
<td>Spiro38</td>
<td></td>
<td>2</td>
<td>2†</td>
<td>45‡</td>
</tr>
</tbody>
</table>

* Tumor thickness is the measured thickness from the surface of the tumor using an optical micrometer.
† Depth of invasion is the measured thickness from the surface of the normal mucosa to the deepest portion of the tumor using an optical micrometer.
‡ The results for oral tongue and floor of mouth were not analyzed separately.
§ A logistic regression model was utilized to predict the risk of cervical metastases by accounting for clinical N stage, tumor differentiation (well = well differentiated; mod = moderately differentiated; poor = poorly differentiated) and depth of muscle invasion.
with a tumor thickness of only 2 mm. Until further investigation clarifies this relationship, the risk of regional metastases should be considered significant for any lesion that exceeds 2 mm in thickness. The association between depth of invasion, tumor thickness, and regional metastatic disease is discussed at length in Chapter 14.

**Treatment**

**Surgical Approaches (That Improve Access)**

Transoral resection of FOM and oral tongue cancer should be performed whenever circumferential tumor-free margins can be obtained with confidence. Frequently, however, transoral resection does not provide the access needed to resect bulky tumors of the oral tongue or tumors with significant extension into the posterior oral tongue or tongue base. FOM, or posterior mandibular alveolar ridge. A cheek flap that is elevated in the gingivobuccal sulcus can provide the access needed when posterior mandibular alveolar ridge or retromolar trigone resection is necessary. However, the mandible frequently precludes surgical access for the optimal resection of tumors of the oral tongue and FOM when the resection margin extends into the lingual alveolar sulcus or posterior oral tongue. Furthermore, performing a reconstruction of a large oral cavity defect that is housed within the confines of the oral cavity or oropharynx via a transoral approach can be inefficient and exasperating. In such cases, surgeons should consider performing either a mandibulotomy or a mandibular lingual releasing approach to improve their exposure. Both of these approaches provide excellent exposure and improve the surgeon’s ability to resect malignancies in a three-dimensional fashion under direct visualization.

**Mandibulotomy**

In the past, resection of neoplasms of the posterior oral cavity and oropharynx was often achieved by resecting the mandible to give “adequate access.” The realization that mandibular resection was unnecessary in the absence of mandibular invasion led to the development of procedures that provided access without mandibular sacrifice. The mandibulotomy, popularized by Spiro and colleagues at Memorial Sloan-Kettering Cancer Center (MSKCC), evolved into the procedure of choice to gain access whenever transloral resection was not feasible. There are several considerations in the optimal performance of a mandibulotomy. Exposure for the mandibulotomy requires a lip-splitting incision. Originally, a straight midline incision was used that extended from the midline of the submental region through the soft tissues of the chin and through the midline of the lip. The straight midline chin-contour incision, a modification that was originally proposed by McGregor, courses around the chin pad and is now the most common incision used. This incision provides a superior aesthetic and functional result when compared with the straight midline incision. Other modifications of this incision have been suggested to optimize the aesthetic outcome. Debate persists regarding the best location to perform the mandibular osteotomy. In situations where the mandible is going to be preserved, a lateral mandibulotomy posterior to the mental foramen is contraindicated, and the osteotomy should be performed anterior to the mental foramen so that lower lip sensation is preserved. However, the best location for a mandibular osteotomy placed anterior to the mental foramen remains unresolved. There are proponents of the midline mandibulotomy as well as of the paramedian or paramidline mandibulotomy. Those who advocate the paramedian mandibulotomy suggest that function is preserved because the procedure does not require division of the geniohyoid and genioglossus muscles. Proponents of the midline mandibulotomy state that the paramedian osteotomy results in reliance on terminal branches of the contralateral inferior alveolar artery to vascularize the ipsilateral parasympathetic mandibular segment. The midline osteotomy also prevents irradiation of the osteotomy site, minimizing radiation-induced sequelae. However, a comparison of midline and paramedian mandibulotomies demonstrated no difference in complication rates. Frequently, the extraction of a mandibular incisor facilitates the execution of an osteotomy, although a midline osteotomy can sometimes be performed without tooth extraction by using a thin osteotomy blade. The unnecessary extraction of periodontally sound teeth should be avoided whenever feasible to optimize dental arch integrity and periodontal health. Some clinicians have converted from a midline osteotomy to a paramedian osteotomy between the lateral incisor and the canine because the roots of these two teeth diverge, facilitating mandibulotomy without dental extraction. Plain film radiography has been used to quantify this relationship, confirming that the angle of divergence between the roots of the lateral incisor and canine was consistently greater than between the central incisors. Moreover, the horizontal distance between the canine and lateral incisor at the level of the alveolar crestal bone was greater than the horizontal distance between the central incisors. Nevertheless, a tooth-sparing osteotomy should be cautiously considered, because the bony alveolar housing of two adjacent teeth can be mutilated by a poorly executed osteotomy.

The preferred type of osteotomy also remains a subject of debate. Osteotomies include the straight, stair-step, and notched osteotomies. The stepped osteotomy was presumed to provide a broader surface for bony apposition and to minimize rotation at the osteotomy site. Critics of this technique, however, point out that more bone is removed at the bone interface during the stair-step and notched osteotomies. Moreover, the use of rigid fixation with titanium plates affords greater stability than wire osteosynthesis, which was the primary method of fixation that was available when stair-stepped osteotomies were initially advocated. No comparative study exists to bolster the use of one osteotomy design over another.

**Surgical Technique (Fig. 11–5).** Typically, an apron incision that extends to the mid-submental region is performed that also provides exposure for performing an ipsilateral neck dissection. In situations where a neck dissection is not performed, the apron incision does not need to extend as
Mandibulotomy. (A) Tumor involving the lateral tongue and FOM that extends into the posterior oral cavity. A mandibulotomy will be performed to improve surgical access. (B) Apron incision extends to the submental crease and is connected to a straight midline chin-contour incision, which is used to split the lip at the midline. (C) The mucosal incision is extended into the labial vestibular sulcus, the mandibular peristemeum is elevated, and a cheek flap is raised to the region of the planned osteotomy. The paramedian osteotomy is placed anterior to the mental foramen between the lateral incisor and the canine. The straight and stair-step osteotomies are depicted. (D) The angle of divergence between the mandibular lateral incisor and canine is greater than between the incisors. However, a tooth-sparing osteotomy should be considered only when adequate alveolar crestal bone exists to house both tooth roots following the osteotomy. (E) The mandible is lateralized and the soft tissues of the FOM are divided, preserving the lingual nerve whenever possible. Excellent access is gained by this approach to facilitate circumferential tumor resection and reconstruction.
far caudally unless the reconstructive phase requires such exposure. When bilateral neck dissections have been performed, a midline incision is created from the apron flap superiorly to the submental crease. The skin incision is continued superiorly from the mid-submental crease using a straight midline chin-contour incision that extends through the lip and into the depth of the labial alveolar sulcus, but an adequate cuff of alveolar mucosa should be left attached to the gingiva to facilitate incisional closure. The mucosal incision is then extended within the labial alveolar sulcus to the region of the mandible corresponding to the site of the mandibular osteotomy that is preferred by the surgeon. The periosteum is elevated in the region of the planned osteotomy in anticipation of placing the mandibular plate and performing the osteotomy. The cheek flap can be elevated by leaving a cuff of soft tissue over the mandible if tumor has invaded the labial cortical plate to ensure complete resection. Care is taken to preserve the mental nerve. The incision is then extended over the alveolar ridge into the lingual sulcus. If necessary, a tooth is extracted at the site of the planned osteotomy. A mandibular reconstruction plate is then fashioned to the shape of the mandible with at least three screw holes drilled on either side of the planned osteotomy. The osteotomy is then performed by using a sagittal saw. If a stair-step osteotomy is performed, the horizontal portion of the osteotomy must be at least 5 mm apical to the apices of the tooth roots to maintain pulpal viability.\textsuperscript{55,56} An incision must be extended posteriorly within the lingual alveolar sulcus to allow for lateralization of the mandible to gain access for tumor resection. The lingual mucosal incision should be designed so that an adequate cuff of lining mucosa remains attached to the mandible to facilitate closure. Dissection is continued through the submucosal tissues, and the mylohyoid muscle must be divided to swing the mandible laterally so that tumor resection can be completed. The lingual nerve can frequently be preserved by dissecting the surrounding soft tissues away from the nerve so that the mandible can be swung laterally. The hypoglossal nerve is preserved unless its preservation would compromise the tumor resection. Preservation of the hypoglossal or lingual nerve may be facilitated by following the nerve from the submandibular triangle into the FOM and tongue.

Following tumor resection, the osteotomy is reapproximated by applying the previously contoured mandibular reconstruction plate. Although a single plate is typically adequate to reduce the osteotomy, a monocortical plate can be applied more superiorly to maximize immobilization and osteosynthesis. Closure of the lingual soft tissues is performed in multiple layers, and reapproximation of the suprathyroid musculature minimizes the risk of fistula formation. The cheek flap is closed in layers, carefully reconstructing the vermilion border and the patient’s preoperative appearance.

**Mandibular Lingual Releasing Approach**

The mandibular lingual releasing approach is a technique that can be employed to improve surgical exposure without performing an osteotomy.\textsuperscript{57,58} This approach is frequently less time-consuming than the mandibulotomy because a reconstruction plate is not required and there is no lip-splitting incision to close. The mandibular lingual releasing approach facilitates surgical resection and reconstruction by providing wide access to the posterior oral cavity and oropharynx.

**Surgical Technique**\textsuperscript{57,58} (Fig. 11–6). A subplatysmal apron flap is elevated superiorly that extends to the inferior border of the mandible, exposing the soft tissues of the neck bilaterally. In most patients with large tumors of the oral tongue or FOM, the apron flap has already been performed to gain exposure so that bilateral neck dissections can be completed. After the submandibular and submental triangle contents have been removed, the suprathyroid musculature can be easily visualized. A mucosal incision is performed along the lingual vestibule of the FOM from first molar to first molar, ideally leaving a 1 cm cuff of lining mucosa attached to the lingual mucogingival junction to optimize closure of the FOM following tumor resection. Tumors that abut the mandible in the FOM may require extension of the incision onto the mucosa of the alveolar ridge to achieve an adequate tumor-free margin. If there are concerns about the relationship of the tumor to the mandible, these concerns may be more effectively addressed via performance of a mandibulotomy.

The mylohyoid, geniohyoid, and digastric muscles are divided bilaterally at their site of attachment to the mandible, and the tongue is freed from the lingual aspect of the mandible by division of the genioglossus muscle. The lingual and hypoglossal nerves, which were identified and preserved during the neck dissections, are preserved until their relationship to the tumor is clarified. The FOM incision is then connected to the dissection performed in the submental and submandibular regions, completely separating the tongue and involved FOM from the uninvolved mandible and lingual sulcular mucosa. A suture is passed through the body of the tongue, which is used to pull the tongue through the FOM into the submental region below the mandible. This approach usually provides transcervical access that extends posterior to the circumvallate papillae, facilitating extensive resections that extend into the base of the tongue (see Fig. 11–7 on p. 107). Reconstruction of the resultant tongue and FOM defect typically requires the use of free tissue transfer, and this approach similarly simplifies transcervical reconstruction.

An incision through the lingual mucoperiosteum of the mandible in dentate patients and on the crest of the mandibular alveolar ridge in edentulous patients was previously advocated, but such an incision can increase the risk of mandibular exposure and devascularization.\textsuperscript{58} A mucosal incision in the FOM is preferred unless attainment of an adequate mucosal margin requires extension onto the mucosa overlying the mandible. A mandibular lingual releasing incision in the lingual alveolar sulcus immediately adjacent to the mandible that leaves inadequate mucosa and submucosa for soft tissue reapproximation increases the risk of postoperative fistula formation and ablation of the lingual alveolar sulcus, which may consequently preclude functional rehabilitation with a removable denture.