Characteristics and Limitations of FDG PET/CT for Imaging of Squamous Cell Carcinoma of the Head and Neck: A Comprehensive Review of Anatomy, Metastatic Pathways, and Image Findings

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OBJECTIVE. This image-based article illustrates the anatomic regions of squamous cell carcinomas of the head and neck and describes the metastatic pathways in and TNM staging for each region. Both the role and limitations of FDG PET/CT in imaging such cancers are discussed, and cases exemplifying these issues are reported. Also included is a discussion of the use of FDG PET/CT to monitor the response of squamous cell carcinomas of the head and neck to therapy, in addition to a brief comparison of PET/CT with such traditional imaging modalities as CT, MRI, and ultrasound.

CONCLUSION. Understanding the characteristics of squamous cell carcinoma of the head and neck, as imaged by FDG PET/CT, is crucial for determining treatment strategy, because it helps to avoid incorrect staging and also provides an accurate assessment of treatment response.

In 2012, the American Cancer Society estimated that 54,560 new cases of head and neck cancer would be diagnosed in individuals in the United States, leading to 10,650 deaths [1]. Almost 90% of head and neck cancers originate in the squamous cell mucosa [2]. The major risk factors for squamous cell carcinoma of the head and neck are tobacco use and alcohol use; risk is increased when either of these factors is present individually, but that risk is multiplied when both factors are present in combination [3]. Human papillomavirus (frequently, human papillomavirus type 16) has been associated with an increased risk for squamous cell carcinoma of the oropharynx [4]. Epstein-Barr virus has also been implicated in increasing the risk for squamous cell carcinoma of the nasopharynx [5]. Our objective is to review the four major regions (oral cavity, nasal cavity, pharynx, and larynx) of the head and neck where cancer develops and to describe the role of FDG PET/CT in the selection of initial and subsequent treatment strategies. In addition, we will discuss the role and limitations of FDG PET/CT in the imaging of cancer of the head and neck. Non–squamous cell carcinomas of the head and neck have variable FDG activity and are beyond the scope of this review.

Staging of Squamous Cell Carcinoma of the Head and Neck

The four major regions where squamous cell carcinoma of the head and neck is found are the oral cavity, nasal cavity, pharynx, and larynx. The pharynx is further subdivided into the nasopharynx, oropharynx, and hypopharynx (Fig. 1A). Squamous cell carcinoma of the head and neck is classified using TNM staging criteria according to the American Joint Committee on Cancer staging manual [6]. The T category is based on the size of the primary tumor and the extent of disease involvement, which are unique in each of the regions and subregions of the head and neck and will be discussed in detail later in this article.

The N category describes the absence or presence of metastasis in the regional lymph nodes. Lymph node imaging characteristics using size criteria and morphologic findings can assist in determining metastatic disease involvement. A variety of size criteria is used for the assessment of metastatic nodes [7]. Some radiologists think that any node larger than 1 cm is abnormal. Others use different size criteria, depending on the lymph node stations (Fig. 1B). One approach is to use the length of the short axis to classify metastatic involvement, with a short axis longer than 1.5 cm (for level 1A and 1B lymph nodes),

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1.0 cm (for level II–VII lymph nodes), or 0.8 cm (for retropharyngeal nodes) serving as a positive marker for disease [6, 7]. The most widely used criteria are known as the long-axis criteria. According to these criteria, a diameter longer than 15 mm (for level I and II lymph nodes) or 10 mm (for all other lymph nodes) suggests the presence of metastasis. However, if size criteria are used alone, the error rate is 8–19% [8].

Morphologic findings may also be used to assess the absence or presence of metastasis. For example, a fatty hilum suggests that the lymph node is benign, whereas central necrosis of a lymph node suggests disease involvement [7]. Nodal shape and grouping of the lymph nodes are also important, especially in cases where, according to size criteria, lymph nodes show borderline enlargement. If a lymph node with borderline enlargement has a nodular shape, then malignancy is more likely. Identification of a cluster of at least three lymph nodes that each have a maximum diameter of 8–15 mm should heighten suspicion for metastasis, especially if the nodes are located in the lymphatic drainage pathway of the primary tumor [7]. Consideration of both size criteria and morphologic findings when assessing metastatic involvement decreases the error rate to approximately 10% [8].

In addition to qualitative data, quantitative data obtained using PET/CT can be a useful tool for lymph node assessment. The most widely used PET/CT parameter is the maximum standardized uptake value, which is considered a means of semiquantitative analysis. It is widely accepted that hypermetabolic lymph nodes with FDG activity on PET/CT examination and a maximum standardized uptake value of more than 2.5 are more likely to be malignant. Combining assessment of FDG activity with the use of size criteria and morphologic findings can further decrease the error rate to 4% [9]. False-positive PET/CT results are common because of reactive nodes, and therefore diagnosis based on identification of positive nodes in tissue is warranted [10].

Lymph node staging is the same for all regions except the nasopharynx, for which there exists a unique staging classification. The staging of lymph nodes of the head and neck is summarized in Table 1 [6], whereas the staging of lymph nodes of the nasopharynx is discussed later in this article. The size of the lymph nodes and evidence of disease involvement in the contralateral nodes can lead to upstaging of the TNM classification.

TABLE 1: Staging of the Lymph Nodes of the Head and Neck, With the Exception of Those in the Nasopharynx

Stage	Definition
NX	Cannot be assessed
N0	No regional nodal metastasis
N1	Single ipsilateral lymph node < 3 cm with metastasis
N2a	Single ipsilateral lymph node > 3 cm but < 6 cm with metastasis
N2b	Multiple ipsilateral lymph nodes < 6 m with metastasis
N2c	Bilateral or contralateral lymph nodes < 6 cm with metastasis
N3	Lymph node > 6 cm with metastasis
U	Located above the lower border of the cricoid cartilage
L	Located below the lower border of the cricoid cartilage

The M category classifies metastatic disease involvement in abnormal distant soft tissue, osseous lesions, or abnormal distant lymph nodes. The MX stage denotes that the extent of distant metastases cannot be determined, whereas M0 denotes no evidence of distant metastases, and M1 denotes the presence of distant metastases. The overall incidence of distant metastases of squamous cell carcinoma of the head and neck is 47%, and the most common site of metastasis is the lungs (80% of cases), followed by the liver and bone (both at 34%) [11]. PET/CT is the modality of choice for the detection of metastases and has a sensitivity, specificity, and accuracy of 92%, 99%, and 98%, respectively, for squamous cell carcinoma of the head and neck, making it superior to such conventional imaging modalities as CT and MRI [12–14].

Oral Cavity

The boundaries of the oral cavity are the lips, buccal mucosa, alveolar ridges with teeth and gingiva, retromolar trigone, floor of the mouth, anterior two thirds of the tongue, and hard palate [15–19] (Fig. 2A). Staging of cancer of the oral cavity is based on the size of the lesion and the extent of disease involvement. The T category classification is T1 when the size of the tumor is smaller than or equal to 2 cm, T2 when the tumor is larger than 2 cm but smaller than or equal to 4 cm, and T3 when the tumor is larger than 4 cm. Stage T4a indicates evidence of moderately advanced local disease involving cortical bone, the deep extrinsic muscle of the tongue (genioglossus, hypoglossus, palatoglossus, and styloglossus), the maxillary sinus, or the skin of the face. Stage T4b denotes evidence of very advanced local disease that either involves the masticator space, pterygoid plates, skull base, or encases the internal carotid artery. Local metastases typically occur in level I–III lymph nodes [15–19]. Approximately 50% of cases of squamous cell carcinoma of the oral cavity present with lymph node metastases [20]. Squamous cell carcinoma of the oral cavity tends to be resistant to chemotherapy radiation treatment, making surgery the treatment choice for this region [21].

Figure 2B shows a patient with squamous cell carcinoma of the oral cavity who had a tumor in the right lateral tongue. A right level IIA lymph node was enlarged and showed abnormal FDG activity on a PET/CT scan, raising suspicion for metastatic disease. No distant metastatic disease was seen on the maximum-intensity-projection image.

Larynx

The boundaries of the larynx are the hyoid bone, epiglottis, thyroid cartilage, and thyroid membrane. The larynx is further subdivided into the supraglottic, glottic, and subglottic regions (Fig. 3A). Squamous cell carcinoma of the larynx involves the supraglottis in 30% of cases, the glottis in 65%, and the subglottis in 5% [22–24].

Supraglottis

According to the American Joint Committee on Cancer staging manual [6], the supraglottic region incorporates subsites that include the suprahyoid epiglottis, infrahyoid epiglottis, aryepiglottic folds (laryngeal aspect), arytenoids, and ventricular bands (false cords). The T stage classification of a supraglottic tumor is T1 when the tumor is limited to one subsite of the supraglottis with normal vocal cord mobility and T2 when the tumor invades the mucosa of more than one subsite adjacent to the supraglottis or glottis or a region outside of the supraglottis (mucosa of the base of the tongue, vallecular, or medial wall of the pyriform sinus) without fixation of the larynx. A T3 classification indicates that the tumor is limited to the larynx with vocal cord fixation; invades the postcricoid area, preepiglottic tissues, or paraglottic space; or causes minor erosion of the thyroid cartilage. Stage T4a indicates moderately advanced local disease that invades the thyroid cartilage or invades the tissues beyond the larynx (trachea, soft tissues of neck including deep extrinsic muscle of the tongue, strap muscles, thyroid, and esophagus). Stage T4b indicates very advanced local disease that invades prevertebral space, encases the carotid artery, or invades mediastinal structures. The supraglottis has a rich lymphatic network that contributes to the early and bilateral spread of tumors to level II, III, and IV lymph nodes of the upper, middle, and lower jugular chain, respectively [21]. For supraglottic squamous cell carcinoma, the incidence of delayed regional lymph node disease is 16%, and that of distant metastasis is 3.7% [25].

Glottis

The glottic region incorporates the true vocal cords, including the anterior and posterior commissures. The region 1 cm below the plane of the true vocal folds is also incorporated into the glottis. The tumor category classification is T1 when the tumor is limited to the vocal cords and vocal mobility is normal, T1a when the tumor is limited to one vocal cord, and T1b when the tumor involves both vocal cords. Stage T2 indicates that there is impaired vocal cord mobility; that the tumor extends to the supraglottis, the subglottis, or both; or that a combination of the aforementioned criteria is present. Stage T3 indicates that the tumor is limited to the larynx and there is evidence of vocal cord fixation, that the tumor invades the paraglottic space, that there is minor erosion of the thyroid cartilage, or that a combination of the aforementioned criteria is present. Stage T4a denotes that the tumor invades the thyroid cartilage, invades tissues beyond the larynx, or both, and stage T4b indicates that the tumor invades the prevertebral space, encases the carotid artery, or invades mediastinal structures. Glottic squamous cell carcinomas tend to metastasize unilaterally. In addition, compared with supraglottic tumors, glottic tumors are detected earlier because they tend to produce a hoarse voice in affected patients; this earlier detection is associated with less regional spread [24]. Lymphatic drainage also is not as common in the glottic region as it is in the supraglottic region [22–24]. For squamous cell carcinoma of the glottis, the incidence of delayed regional lymph node disease is 4.4%, and that of distant metastasis is 4% [25].

Subglottis

The subglottic region extends from 1 cm below the true vocal folds to the trachea. The subglottis is an uncommon location for the origination of squamous cell carcinoma, but it tends to be involved when the tumor extends from the glottis or supraglottis (known as a "transglottic tumor") [22–24]. The tumor category classification is T1 when the tumor is limited to the subglottis, T2 when the tumor extends to the vocal cord(s) and there is either normal or impaired mobility, and T3 when the tumor is limited to the larynx and vocal cord fixation is present. The classification is T4a when the tumor invades the cricoid or thyroid cartilage, invades tissues beyond the larynx, or does both. Stage T4b indicates that the tumor invades the prevertebral space, encases the carotid artery, or invades mediastinal structures. Subglottic squamous cell carcinomas tend to metastasize to the paratracheal lymph nodes group (level VI) and either the middle or lower jugular lymph node (levels III and IV, respectively) groups. This leads to understaging of squamous cell carcinoma of the subglottis if the metastatic lymph nodes are not detected, and it also leads to treatment failure resulting from the radiation field being too small [22–24]. For squamous cell carcinoma of the subglottis, the incidence of delayed regional lymph node disease is 11.5%, and that of distant metastasis is 14% [25].

Figure 3B shows a patient with squamous cell carcinoma of the larynx who had a tumor that originated in the supraglottic epiglottis and extended inferiorly to the tracheal cartilage rings, making it a transglottic tumor. The tumor abutted the left tracheal cartilage and involved the left arytenoid and cricoid cartilages. There was no evidence of lymph node involvement or distant metastases.

Pharynx

The pharynx is subdivided into the nasopharynx, oropharynx, and hypopharynx (Fig. 1A).

Nasopharynx

The boundaries of the nasopharynx are the posterior choana, torus tubarius mucosa, eustachian tube, fossa of Rosenmüller, and the posterior pharynx wall (Fig. 4A). The skull base is the superior boundary, and the soft palate is the inferior boundary [26]. The tumor stage classification is T1 when the tumor is confined to the nasopharynx. Stage T2 indicates that the tumor extends to the soft tissues, with stage T2a denoting that the tumor extends to the oropharynx, the nasal cavity, or both, without parapharyngeal extension, and with stage T2b denoting that the tumor extends into the parapharyngeal space. Stage T3 indicates that the tumor involves bony structures, the paranasal sinuses, or both. Stage T4 denotes that there is intracranial extension of the tumor; that the tumor involves the cranial nerves, infratemporal fossa, hypopharynx, orbit, or masticator space; or that a combination of the two criteria is present [26]. Local metastases commonly occur in level II–V retropharyngeal and parapharyngeal lymph nodes. At the time of presentation, approximately 85% of patients have lymph node involvement, which is bilateral in 50% of cases [27].

Staging of regional lymph nodes in the nasopharynx is different from staging of the lymph nodes in the other regions of the head and neck. The tumor stage classification is N0 when there is no evidence of regional lymph node metastasis. Stage N1 denotes that there is unilateral metastasis in lymph nodes smaller than or equal to 6 cm located above the supraclavicular fossa, whereas stage N2 indicates that there are bilateral metastases in lymph nodes smaller than or equal to 6 cm located above the supraclavicular fossa. Stage N3 is subdivided into two groups, with N3a denoting the presence of metastasis in lymph nodes larger than 6 cm and N3b denoting the presence of metastasis in the supraclavicular fossa [26].

Figure 4B shows a patient with squamous cell carcinoma of the right nasopharynx who had a tumor that crossed the midline and invaded the right carotid canal. Bilateral level lymph nodes were enlarged, had intense FDG activity noted on PET/CT scans, and showed evidence of central necrosis that was characteristic of metastatic disease. There were no distant metastases.

Oropharynx

The boundaries of the oropharynx are the hyoid bone, base of the tongue, soft palate, uvula, posterior wall, epiglottis, vallecula, tonsils, posterior tonsillar pillar, and anterior tonsillar pillar [17–19, 28–30] (Fig. 5A). Staging of tumors of the oropharynx is determined on the basis of the size of the lesion and the extent of disease involvement. The tumor category classification is T1 when the tumor is smaller than or equal to 2 cm, T2 when the tumor is larger than 2 cm but smaller than or equal to 4 cm, and T3 when the tumor is larger than 4 cm. Stage T4a denotes the presence of moderately advanced local disease involving the larynx, deep extrinsic muscle of the tongue, medial pterygoid, hard palate, or mandible. Stage T4b indicates the presence of very advanced local disease that involves the lateral pterygoid muscle, pterygoid plates, lateral nasopharynx, or skull base; or encases the carotid artery; or includes any combination of the aforementioned. Local metastases typically occur in level II and III lymph nodes and in retropharyngeal lymph nodes. At presentation, 70% of ipsilateral lymph nodes have metastases and 30% have bilateral node involvement [31]. Oropharyngeal squamous cell carcinoma responds best to radiotherapy, particularly when caused by human papillomavirus type 16, and it is associated with a 3-year survival rate of 82%, compared with 57% in patients without human papillomavirus [28].

Figure 5B shows a patient with squamous cell carcinoma of the oropharynx who had a tumor originating in the right tonsil. PET/CT examination revealed that two right level IIA lymph nodes had intense FDG activity that was characteristic of metastatic disease. There was no scintigraphic evidence of distant metastatic disease.

Figure 5C shows a second patient with squamous cell carcinoma of the oropharynx who had a tumor in the right base of the tongue. On PET/CT examination, bilateral level IIA lymph nodes had intense FDG activity that was characteristic of metastatic disease. No evidence of distant metastatic disease was noted on the maximum-intensity-projection image.

Hypopharynx

The boundaries of the hypopharynx are the posterior cricoid cartilage, posterior pharyngeal wall, pyriform sinuses, and retropharyngeal fat (Fig. 6A). The superior boundary is the level of hyoid bone, and the inferior boundary is the lower border of the cricoid cartilage.

Classification of hypopharyngeal tumors is determined on the basis of the size of the lesion and the extent of disease involvement. Stage T1 denotes a tumor that is smaller than or equal to 2 cm and is limited to one subsite. Stage T2 denotes the presence of a tumor that is larger than 2 cm but smaller than or equal to 4 cm and the absence of fixation of the hemilarynx or more than one subsite. Stage T3 denotes evidence of either a tumor larger than 4 cm or fixation of the hemilarynx. Stage T4a denotes evidence of moderately advanced local disease involving the thyroid or cricoid cartilage, hyoid bone, thyroid gland, esophagus, or soft tissue of the central compartment, whereas stage T4b denotes the presence of very advanced local disease that involves the prevertebral fascia, encases the carotid artery, or involves mediastinal structures.

Local metastases typically occur in level II–IV lymph nodes and retropharyngeal lymph nodes [23, 28]. Hypopharyngeal squamous cell carcinoma can spread via the submucosa with skip lesions [28]. Even with stage N0 disease, the risk of micrometastases occurring in association with squamous cell carcinoma of the hypopharynx has been reported to be as high as 40% [32]. The incidence of delayed regional lymph node disease at 2 years after therapy is 18–31%, and that of distant metastasis is 17% [25].

Figure 6B shows a patient with squamous cell carcinoma of the hypopharynx who had a tumor that extended anteriorly and involved the hyoid bone. PET/CT examination revealed that a right level III lymph node had moderate FDG activity that indicated possible metastatic disease. There was no scintigraphic evidence of distant metastatic disease.

Nasal Cavity

The boundaries of the nasal cavity are the skull base, internal naris, hard palate, and external naris (Fig. 7A). The tumor category classification is T1 when the tumor is confined to the nasal cavity or ethmoidal sinus, with or without bone erosion, and T2 when the tumor invades two subsites in a single region or extends to involve an adjacent region within the nasoethmoidal complex, with or without bony invasion. Stage T3 indicates that the tumor extends to invade the medial wall or floor of the orbit, maxillary sinus, palate, or cribriform plate. Stage T4a denotes the presence of moderately advanced local disease when the tumor invades the anterior orbital contents or skin of nose or cheek and is minimally extended to the anterior cranial fossa, pterygoid plates, or sphenoid or frontal sinuses. Stage T4b indicates the presence of very advanced local disease, with the tumor invading the orbital apex, dura, brain, middle cranial fossa, cranial nerves other than V2, nasopharynx, or clivus [6]. At presentation, local metastases typically occur in level I–II lymph nodes, with an incidence of approximately 13% [33]. Distant metastases rarely occur.

Figure 7B shows a patient with squamous cell carcinoma of the left nasal cavity who had a tumor that invaded the left nasal bone and the orbit of the left eye. There was no scintigraphic evidence of lymph node involvement or distant metastatic disease.

Roles and Limitations of PET/CT in Imaging of the Head and Neck

Current practice is to use MRI and CT with contrast agent to define primary tumors of the head and neck, because these imaging modalities provide higher anatomic resolution than does FDG PET/CT; however, numerous reports on initial staging indicate that the sensitivity of PET/CT is equivalent to that of MRI and CT [34]. FDG PET/CT does have an advantage in staging nodal disease, offering a sensitivity of 90% and a specificity of 94%, compared with CT (sensitivity, 82%; specificity, 85%), MRI (sensitivity, 80%; specificity, 79%), and ultrasound (sensitivity, 72%) [35]. In addition, FDG PET/CT detects distant metastases or a second primary tumor in up to 15% patients with squamous cell carcinoma of the head and neck, with true-positive findings noted for 82%; such findings can significantly alter treatment planning [34]. FDG PET/CT has been shown to alter the management of 13.7–55% of patients with squamous cell carcinoma of the head and neck [36–38]. Research is currently being conducted to examine the use of FDG PET/CT as a prognostic tool for squamous cell carcinomas of the head and neck, with studies determining that patients who have a primary tumor with a maximum standardized uptake value greater than 9.0 have an inferior disease-free survival [39, 40].

Many studies have revealed that FDG PET/CT performed after initial chemoradiotherapy has a high specificity (90–95%) and a high negative predictive value (92–97%), adding confidence to exclusion of disease recurrence, and that it can be used to defer lymph node dissections [41–44]. However, the main limitation of FDG PET/CT is low sensitivity (35–71%) and a positive predictive value (38–50%) necessitating the concurrent use of traditional imaging modalities for disease surveillance [42–44]. In addition, it is important to appropriately time imaging after radiotherapy, to reduce the false-positive results associated with inflammation. In general, it is suggested that PET/CT be performed 8–12 weeks after completion of radiation therapy [10, 45].

FDG accumulates in tissue affected by squamous carcinoma cells more often than in healthy tissue, because squamous carcinoma cells primarily use glycolysis for cellular metabolism, even in aerobic conditions; this is known as the Warburg effect [46]. Unfortunately, WBCs that are activated by the inflammatory cascade use a similar glycolytic metabolism that leads to increased FDG uptake in the settings of infection and inflammation [47, 48]. FDG uptake in nodes reactive to recent biopsy or inflammation resulting from ulceration of the primary tumor is a source of false-positive or equivocal activity in the lymph nodes. Another type of false-positive PET scan result can occur in association with postradiation treatment, when ulcers are prone to develop secondary to mucosal breakdown and will have a corresponding increase in abnormal FDG activity [49, 50] (Fig. 8A). Tracheosophageal puncture, which is used for phonation after laryngectomy, will result in increased FDG activity corresponding to expected inflammation and should not be mistaken for recurrent disease (Fig. 8B). In addition, postsurgical sites are prone to infection, especially after radiation treatment (Fig. 9A). On follow-up imaging, independent infections (e.g., pneumonia), reactive lymph nodes, or sarcoidosis (Fig. 9B) could mimic metastatic disease. A patient with oropharyngeal squamous cell carcinoma who received treatment had independent lung infection with reactive lymph nodes noted on follow-up imaging, but no evidence of metastatic disease was found by biopsy (Fig. 10A).

A PET scan provides a false-negative result for lymph node involvement when nodes are necrotic, because there is too little viable tissue for detection. Although scans of necrotic lymph nodes may show either a mild ring of FDG activity at the periphery or no evidence of FDG uptake, the corresponding CT images usually reveal enlarged centrally hypodense lymph nodes consistent with metastatic necrotic lymph nodes [7] (Fig. 10B). Cystic lymph nodes are frequently seen in association with human papillomavirus–positive oropharyngeal cancers. Radiologists should be careful not to misdiagnose a cystic level II lymph node as a brachial cleft cyst [7]. In addition, it is difficult to assess cystic lymph nodes with PET/CT. Use of contrast-enhanced CT with PET results in more accurate evaluation of lymph nodes [7].

Metabolically active brown fat throughout the head and neck can be easily mistaken for metastatic lymph nodes, but the corresponding CT images show tissue density consistent with fat [51] (Fig. 11A). Fasciculations in the remaining denervated tongue, which are a postsurgical finding after hemiglossectomy, have intense FDG activity. The abnormal FDG activity resulting from fasciculations should not be mistaken for recurrent tumor (Fig. 11B). This same phenomenon can occur in association with muscles of flap reconstructions and, again, should not be confused with disease recurrence.

Another use for PET/CT imaging of head and neck cancer is to locate an unknown primary tumor site after lymph node biopsy reveals squamous cell carcinoma. PET/CT can detect the primary site of head and neck malignancy in 25–56% of cases for which standard imaging modalities are unable to locate the primary tumor [10, 52, 53]. Knowledge of lymphatic drainage in the head and neck, in addition to PET/CT information, can direct which regions to search for the presence of a primary tumor.

One of the limitations of performing PET/CT after treatment is the observation of asymmetric FDG activity in paired structures in the head and neck, occurring either as a normal variant or consequent to radiation of one side or surgical removal of one side. This asymmetry in FDG activity of the head and neck can lead to the misinterpretation that there is contralateral disease involvement. However, it is well known that the anatomic changes resulting from surgery or radiation significantly limit the use of CT and MRI for the detection of recurrence, whereas FDG PET/CT maintains 83–100% sensitivity, 78–98% specificity, and 81–98% accuracy for the detection of recurrent disease [34].

PET/CT of the head and neck can be limited because of dental amalgam or mandible reconstruction orthopedic hardware, which can create an abnormal increase in FDG activity resulting from attenuation correction artifact [54]. Detection of small nodal metastases smaller than 7 mm is limited by PET scanner resolution and partial volume effect, which can limit the use of PET/CT, especially for clinically confirmed cases of stage N0 disease [55].

Discussion

Understanding the characteristics of squamous cell carcinoma of the head and neck as seen on FDG PET/CT scans is crucial for selecting treatment strategies and assessing treatment response. In addition, knowledge of the limitations of FDG PET/CT for imaging cancer of the head and neck can avoid incorrect TNM staging and ensure proper assessment of response to therapy.

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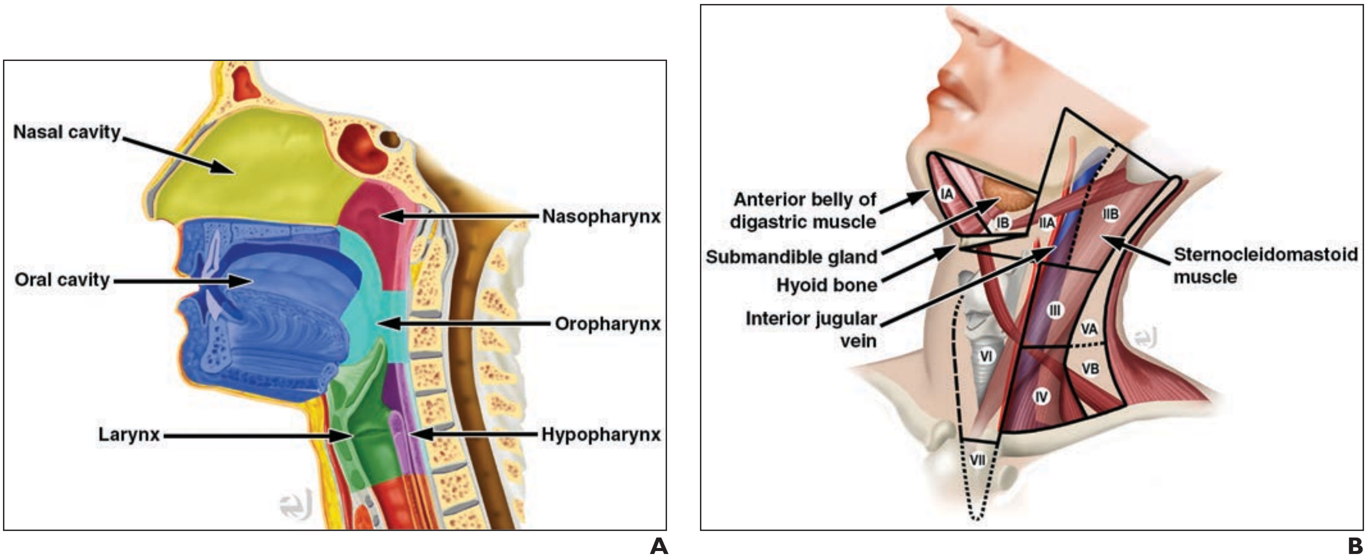


Fig. 1—Four major regions where squamous cell carcinoma of the head and neck is found.
A and **B,** Illustrations showing regions of head and neck where squamous cell carcinoma develops (**A**) and lymph node stations (**B**). (Drawings by Jablonowski E. Reprinted with permission [22])

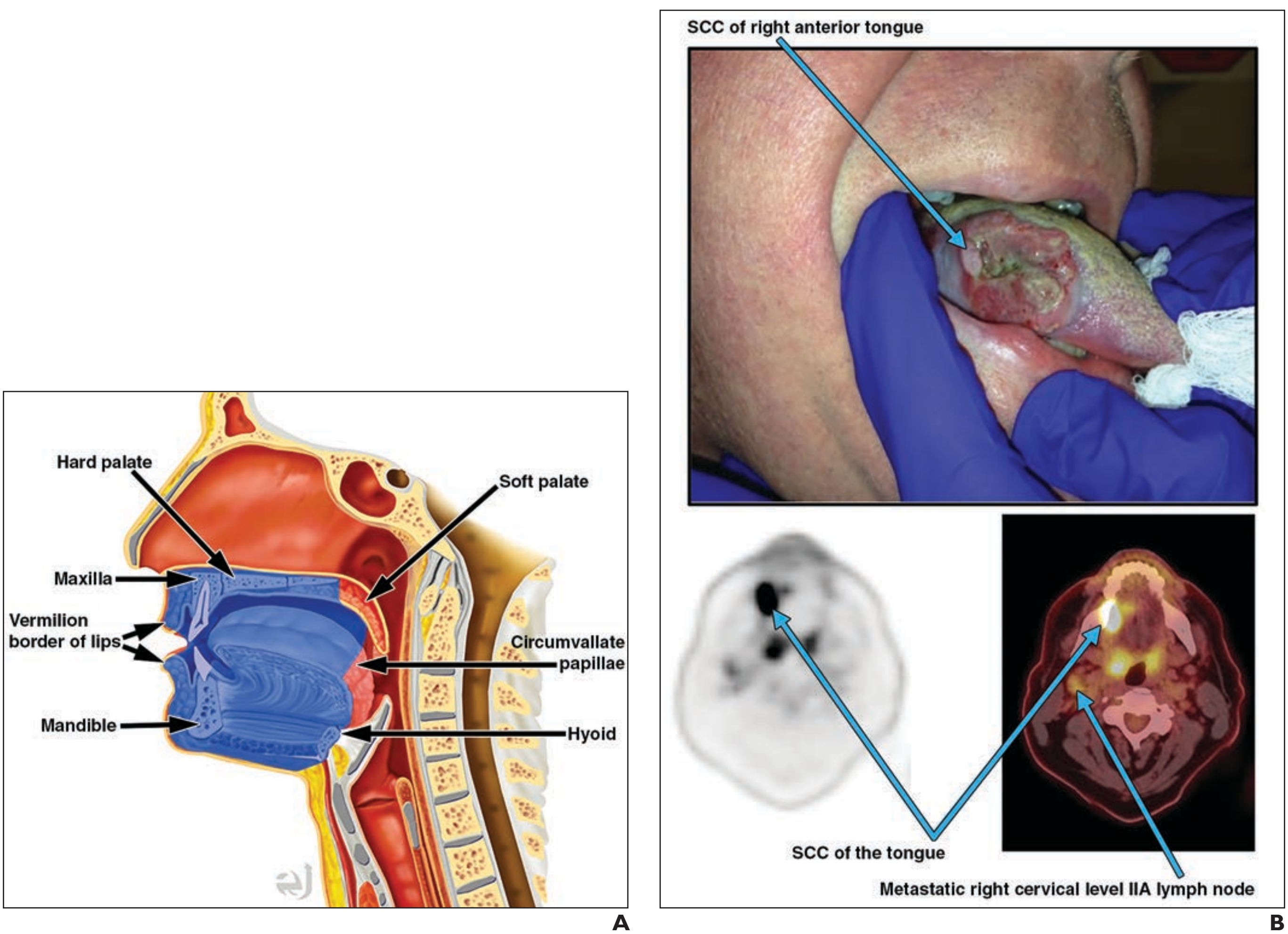


Fig. 2—Oral cavity.
A, Illustration of oral cavity boundaries. (Drawing by Jablonowski E. Reprinted with permission [22])
B, 56-year-old man with squamous cell carcinoma (SCC) of tongue. Photograph and PET/CT images show SCC of right oral tongue with right level IIA metastatic lymph node.

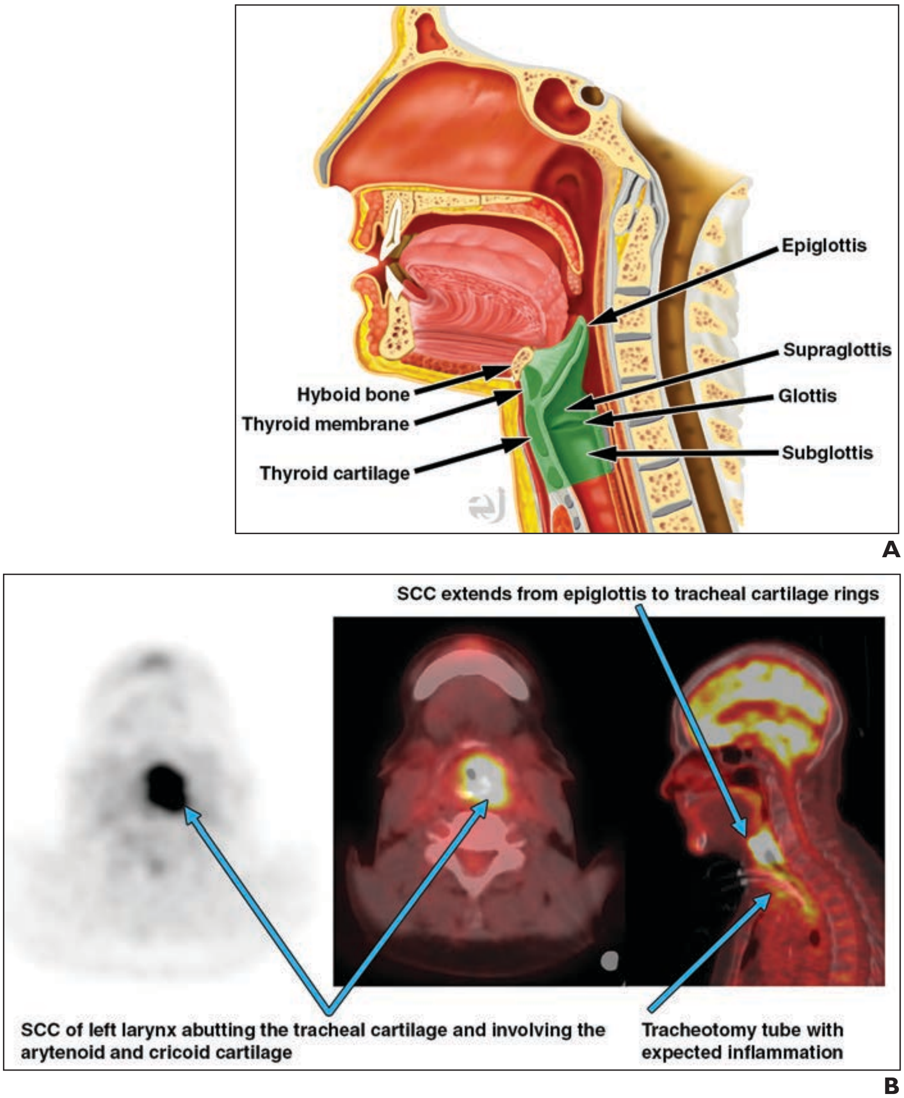


Fig. 3—Larynx.
A, Illustration of boundaries of larynx. (Drawing by Jablonowski E. Reprinted with permission [22])
B, 75-year-old man with transglottic squamous cell carcinoma (SCC). PET/CT images show transglottic SCC originating in supraglottic epiglottis and extending inferiorly to tracheal cartilage rings.

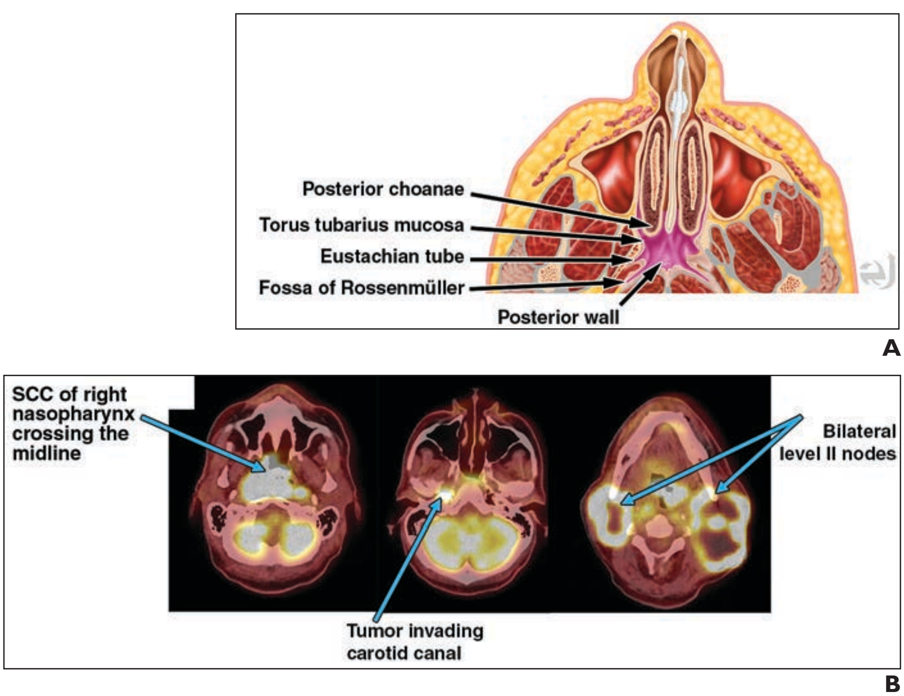


Fig. 4—Nasopharynx.
A, Illustration of boundaries of nasopharynx. (Drawing by Jablonowski E. Reprinted with permission [22])
B, 57-year-old man with nasopharyngeal squamous cell carcinoma (SCC). PET/CT images show SCC of right nasopharynx invading carotid canal and also show bilateral metastatic lymph nodes.

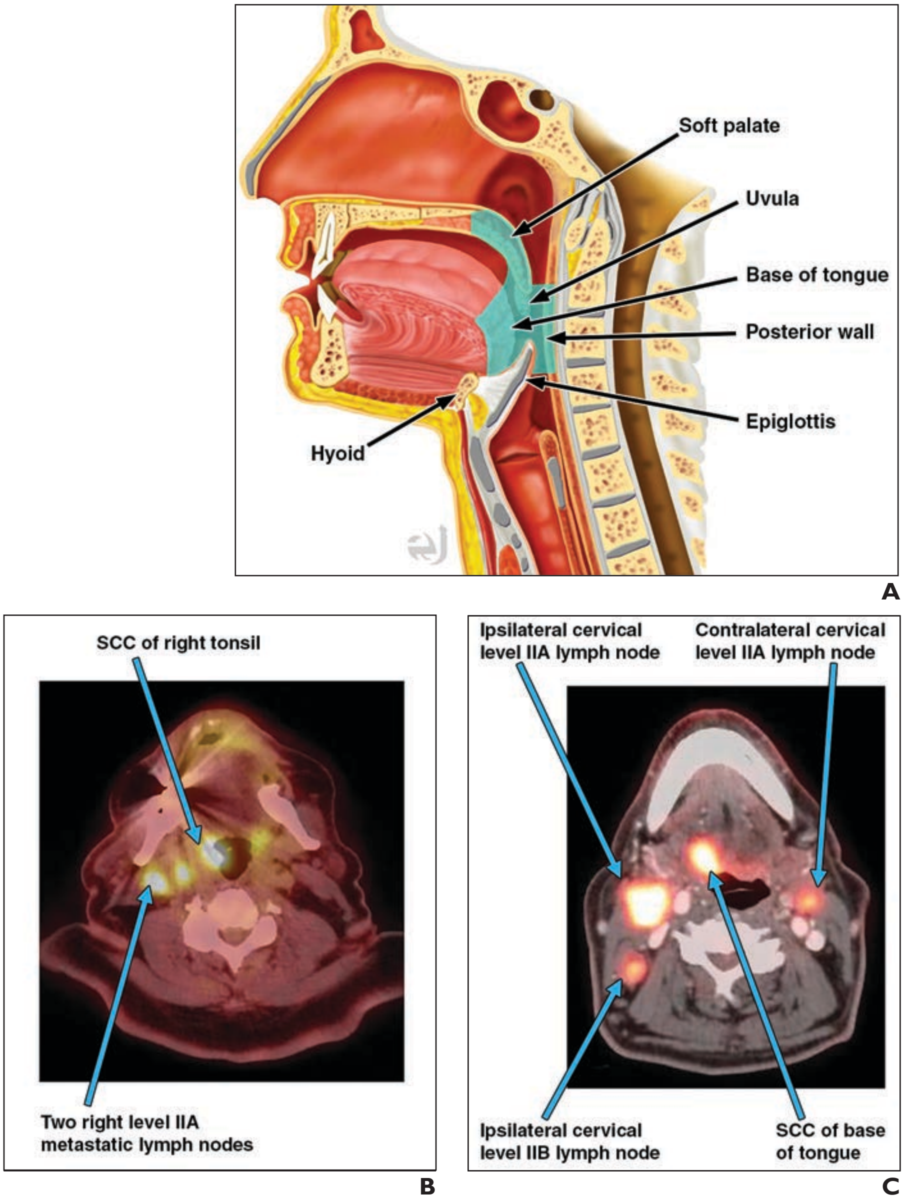
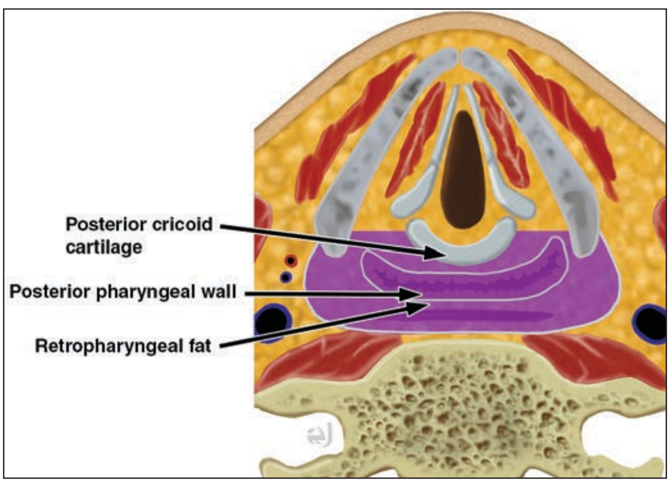
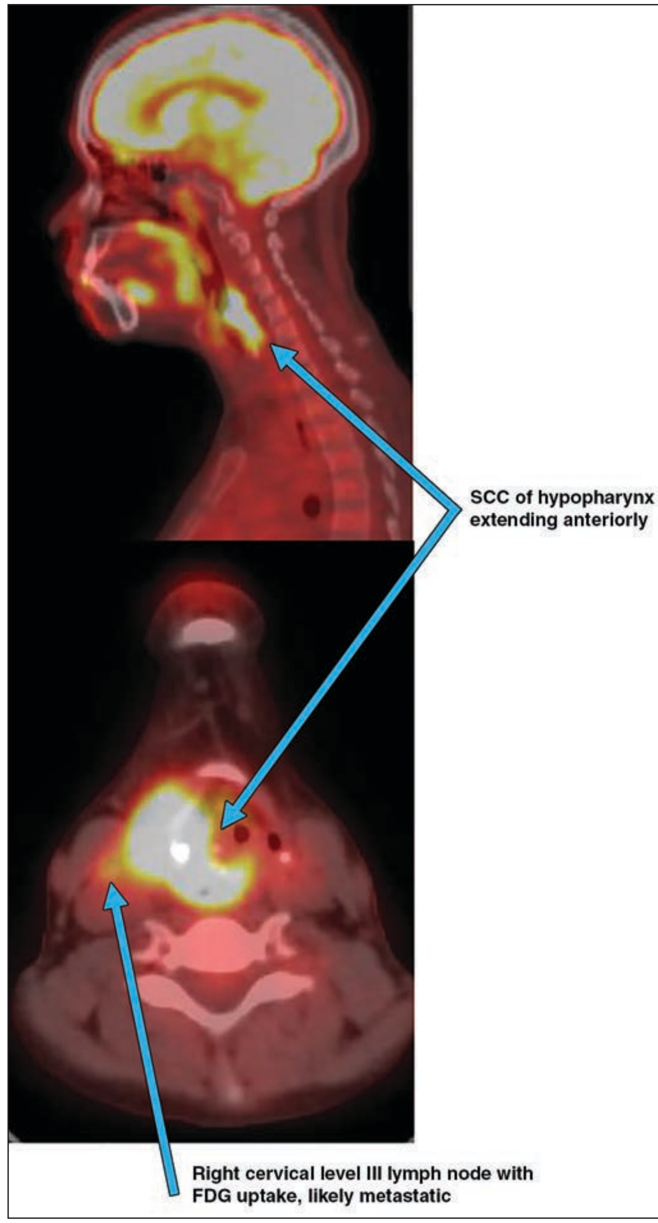


Fig. 5—Oropharynx.
A, Illustration of boundaries of oropharynx. (Drawing by Jablonowski E. Reprinted with permission [22])
B, 62-year-old man with squamous cell carcinoma (SCC) of right tonsil with two right metastatic level IIA lymph nodes.
C, 60-year-old man with SCC of base of tongue. PET/CT image shows oropharyngeal SCC of base of tongue with bilateral metastatic level IIA lymph nodes.



A



B

Fig. 6—Hypopharynx.
A, Illustration of boundaries of hypopharynx. (Drawing by Jablonowski E. Reprinted with permission [22])
B, 46-year-old woman with squamous cell carcinoma (SCC) of hypopharynx. PET/CT images show hypopharyngeal SCC involving hyoid bone with metastasis of right level III lymph node.

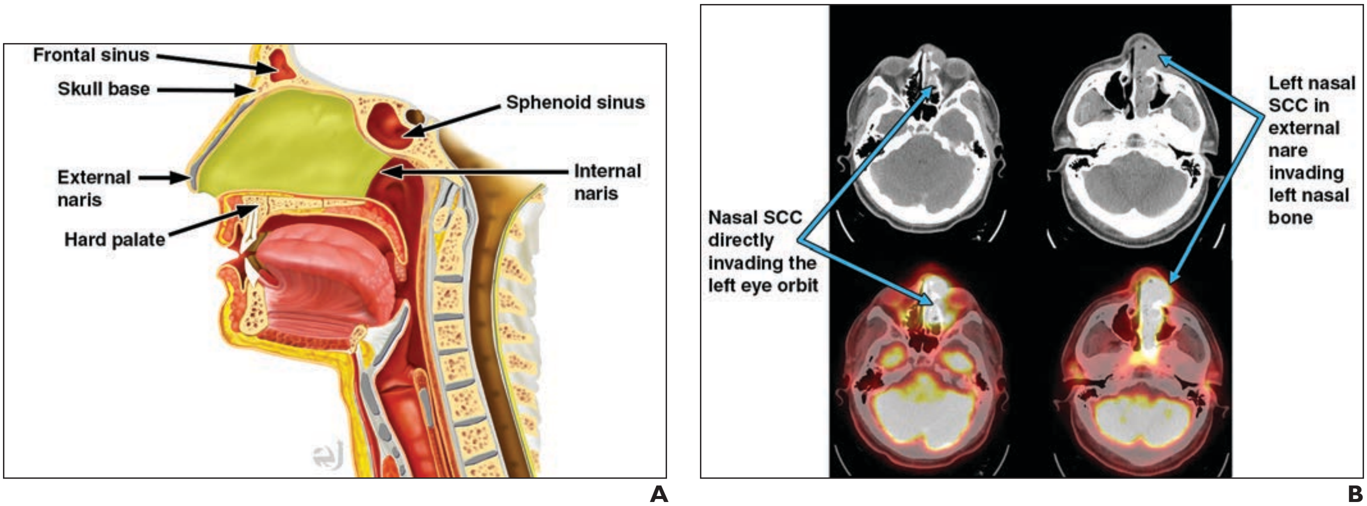


Fig. 7—Nasal cavity.
A, Illustration of boundaries of nasal cavity. (Drawing by Jablonowski E. Reprinted with permission [22])
B, 42-year-old man with left nasal squamous cell carcinoma (SCC). PET/CT images show osseous destruction and orbital extension.

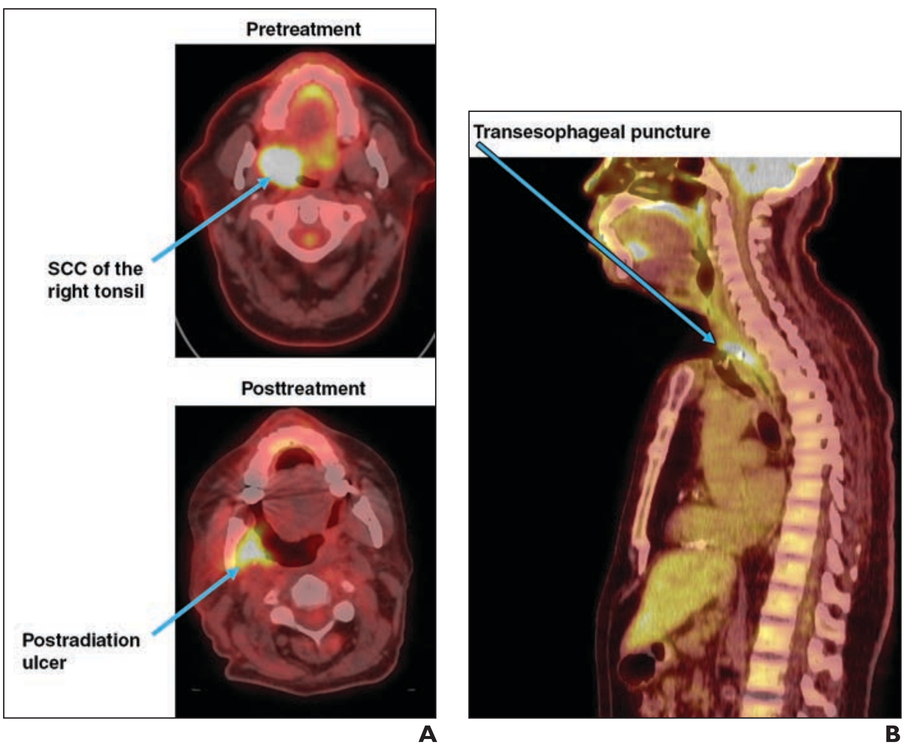
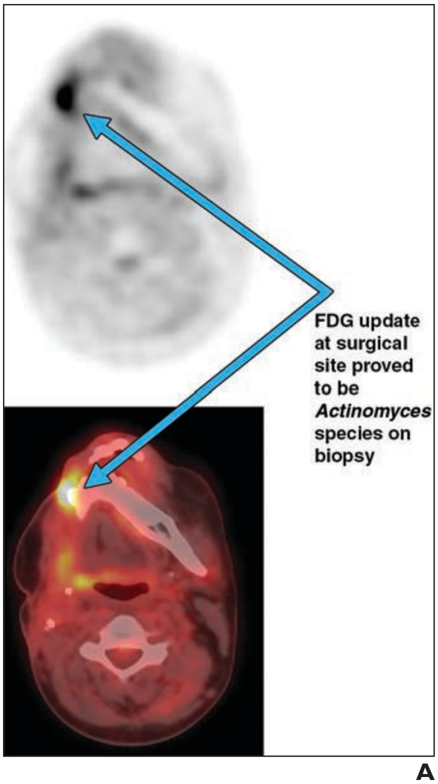


Fig. 8—Examples of false-positive PET scan results resulting from treatment procedures.
A, 54-year-old man with squamous cell carcinoma (SCC) of tonsil. False-positive PET scan result showing increased FDG activity of ulcers after radiation treatment.
B, 46-year-old woman with laryngeal SCC.



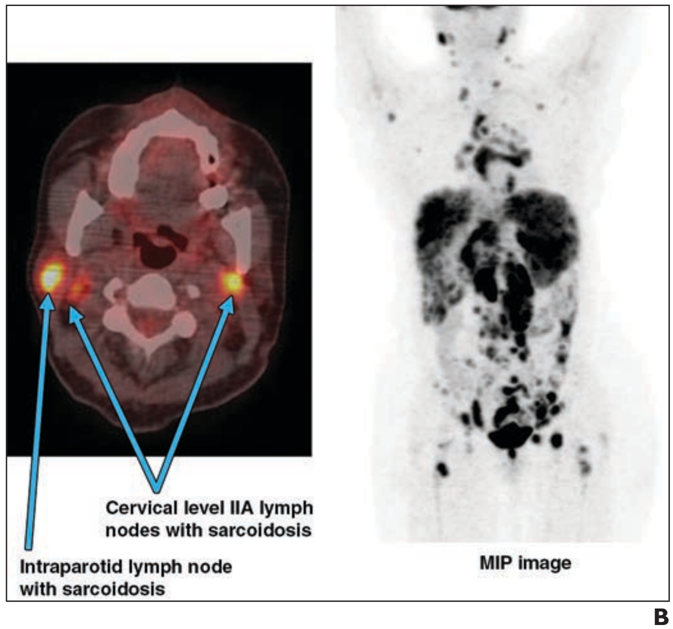
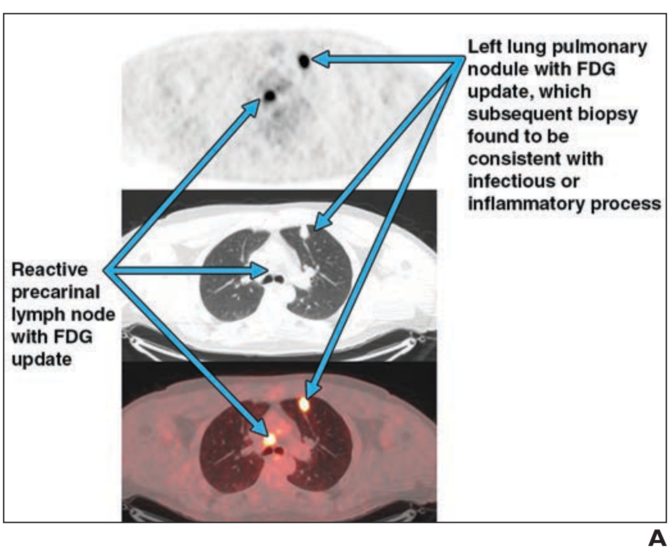


Fig. 9—Examples of infection or sarcoidosis shown on PET scans.
A, 51-year-old man with oral squamous cell carcinoma (SCC). PET scan shows postsurgical *Actinomyces* species infection.
B, 45-year-old woman with lymphoma. Follow-up PET scan shows sarcoidosis mimicking metastatic lymph node disease with enlarged hypermetabolic bilateral lymph nodes. Sarcoidosis was active throughout entire body, as shown in maximum-intensity-projection image (MIP).



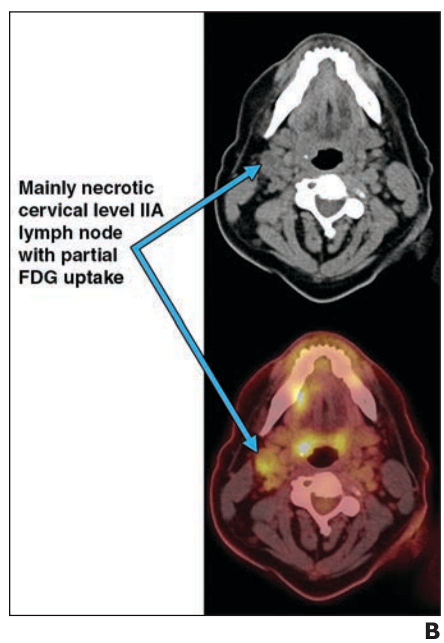
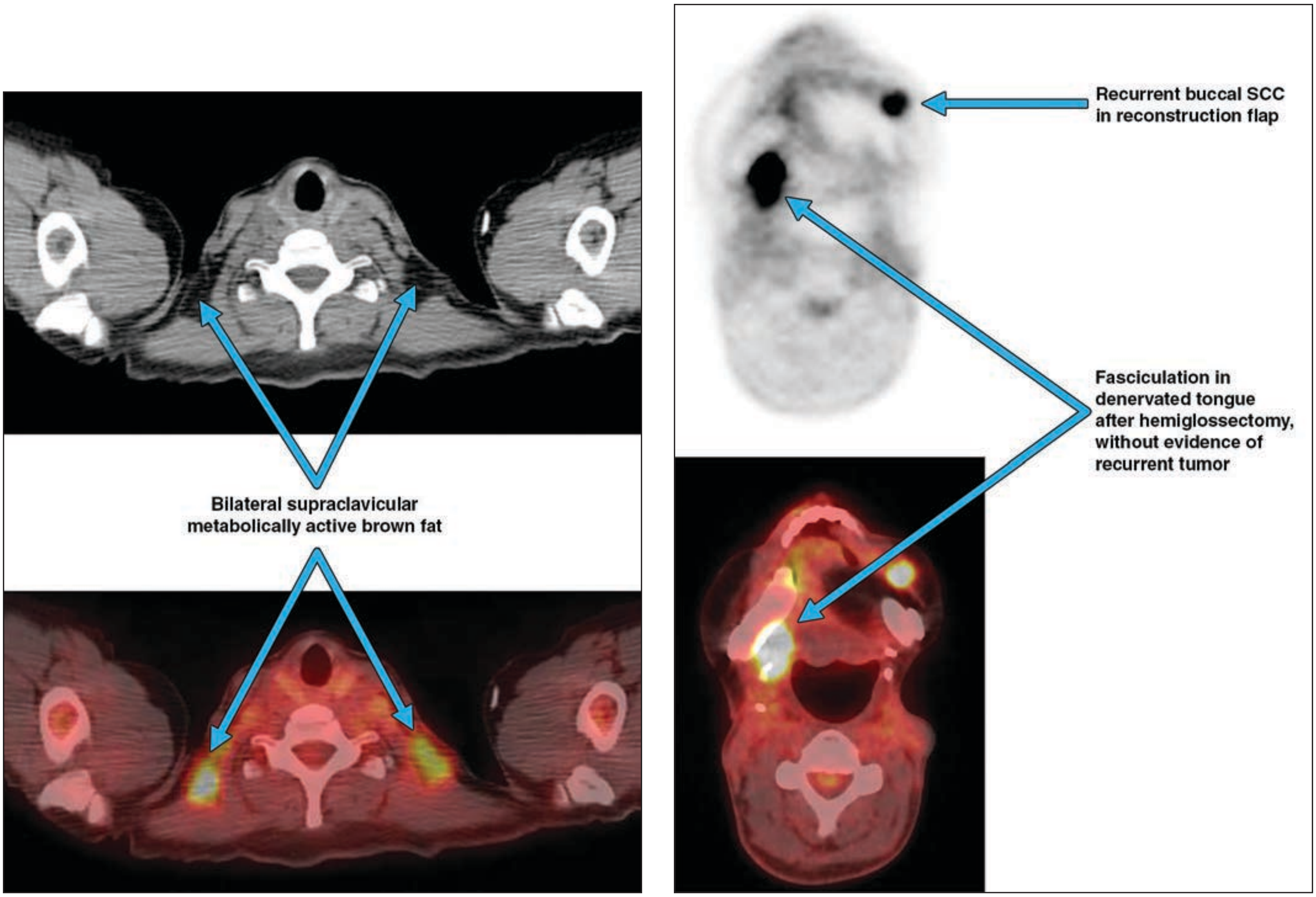


Fig. 10—Appearance of lymph nodes on PET and CT scans of patients with squamous cell carcinoma (SCC).
A, 49-year-old man with oropharyngeal SCC. PET scan with independent lung infection with reactive lymph nodes and no evidence of metastatic disease, as proven by biopsy.
B, 56-year-old man with SCC of oral tongue. PET scan shows necrotic level IIA lymph nodes with lower than expected FDG uptake. Corresponding CT image shows enlarged centrally hypodense lymph nodes consistent with metastatic disease.



A B

Fig. 11—Appearance of brown fat and fasciculations on PET.
A, 41-year-old woman with Hodgkin lymphoma. Metabolically active brown fat throughout head and neck can be easily mistaken for metastatic lymph nodes on PET scan. Corresponding CT images show tissue density consistent with fat and no lymph nodes.
B, 38-year-old woman with oral squamous cell carcinoma (SCC). Postsurgical tongue fasciculations in remaining denervated tongue after hemiglossectomy have intense FDG activity on PET and should not be mistaken for recurrent tumor.