Neck, Oropharynx, and Nasopharynx

The technical considerations applicable to head and neck magnetic resonance imaging (MRI) are similar to those involved in non-neurologic imaging of other areas of the body: maximizing the signal-to-noise ratio (SNR) within an acceptable imaging time, optimizing contrast among abnormalities, fat, and muscle, and achieving satisfactory spatial resolution. In addition to the choice of pulse sequence, imaging plane, slice thickness, number of acquisitions, and matrix size, attention should be paid to the choice of imaging coil. The oropharynx and nasopharynx, paranasal sinuses, salivary glands, and facial bones are usually imaged with a standard head coil. However, to maximize SNR, the smallest-diameter cylindrical coil (with the highest SNR) that can be fitted to a given patient’s head and that provides an adequate field of view should be used. Superficial structures may be best imaged using a surface coil. Today specialized coils for the head and neck (with both anterior and posterior components) are available for most MRI scanners and should be used to image structures below the face.

As in all of MRI, the choice of pulse sequences is crucial in determining the diagnostic quality of the examination. MRI of the head and neck has been performed almost entirely with spin echo (and fast spin echo) sequences. Use of both heavily T₁-weighted and T₂-weighted sequences is essential in the examination of this region. To attain adequate T₁-weighting, a time to repetition (TR) of less than 600 msec should be used with the shortest time to echo (TE) attainable (5–15 msec). For adequate T₂ weighting, a TR of 2000 to 3000 msec should be used. A TR in the upper part of this range is necessary with higher field (1.5 T) units to achieve comparable T₁-weighting because of the prolongation of T₁ with increasing field strength. As with most of MRI, fast spin echo sequences have generally replaced spin echo scans for acquisition of T₂-weighted images. Fat suppression is commonly used in head and neck imaging, in particular on postcontrast scans to highlight enhancing lesions.

T₁- and T₂-weighted sequences prove complementary in imaging of the head and neck. The short TR, short TE, T₁-weighted scan provides essentially anatomic information and is useful in analyzing the architectural distortion of tissues, disruption of fat planes, mass effect, and adenopathy. The T₂-weighted scan provides higher contrast between pathologic and normal tissues, providing improved localization of the pathologic process. The actual signal characteristics of most pathologic tissues in the head and neck are nonspecific, with the exceptions of cystic and lipomatous lesions.

Optimal slice thickness varies with the abnormality being examined, but a 5-mm thickness (and a 10% to 20% gap between slices) is usually suitable for evaluating this anatomic region. The number of acquisitions and matrix size to be used will vary with the technical capabilities of the scanner and coil. Because T₁-weighted images are usually obtained for anatomic information, the matrix size should be at a minimum 256 × 256, with consideration given to larger matrices or choice of a smaller field of view. With the T₂-weighted scan, fine spatial resolution is relatively less crucial. Scan times should be kept short to minimize image degradation from patient motion. Motion compensation techniques such as gradient moment nulling may be helpful to improve overall image quality.

An initial imaging plane must be chosen that can be used as a localizer for the remainder of the exam. The sagittal plane is usually chosen for the localizer. In general, the axial plane is the most informative single plane, and images in this plane are obtained in most examinations of the oropharynx and nasopharynx, salivary glands, and neck. Images in the coronal and sagittal planes are helpful adjuncts, and at least one of these additional planes is acquired in most exams. The sagittal plane is most helpful in evaluating midline lesions, and the localizer image may be tailored for this purpose by choosing a thin slice thickness and small pixel size (with a sufficiently high number of averages or acquisitions to ensure good image quality). The coronal plane is useful for evaluating laterally located abnormalities and side-to-side symmetry. To facilitate interpretation, both T₁- and T₂-weighted images should be obtained in one of the planes, typically the axial. One or both of the adjunctive planes may then be obtained using a single-pulse sequence.

Intravenous contrast enhancement, using the gadolinium chelates, has a major role in head and neck MRI, as it does in MRI of the head and spine. Contrast use is recommended in exams in which neoplastic involvement or infection is questioned. Normal structures with pronounced vascularity, such as the mucosal lining of the pharynx, exhibit prominent enhancement after intravenous gadolinium chelate administration. One excellent check to make sure that the dose of contrast has not been infiltrated is to inspect the nasal turbinates, which, being highly vascular, exhibit marked enhancement. Inflamed and thickened mucosa, which exhibits prominent enhancement, is clearly demonstrated and differentiated.
on postcontrast scans from nonenhancing retained secretions, retention cysts, and mucoceles. This differentiation is often also possible on unenhanced T2-weighted scans and so may not require the use of contrast. As with CT, vascular tumors such as paraganglioma, neural tumors, angiofibroma, chordoma, and carcinoma exhibit prominent enhancement. Postcontrast scans are extremely useful in assessing extension of head and neck tumors into areas that are otherwise difficult to evaluate, such as intracranially, into muscles, and into small fossae and fissures (e.g., the pterygopalatine fossa). Small mucosal and mesenchymal tumors may also be easier to identify after contrast administration.

**NOSE AND NASOPHARYNX**

MRI has great utility in evaluating mass lesions of the nose and nasopharynx. The indications for an MRI exam of this region are basically fourfold: suspicion of an occult nasopharyngeal carcinoma; documentation of the extent of deep invasion by a known nasopharyngeal carcinoma; evaluation of large, benign lesions; and assessment of a deep, parapharyngeal lesion inaccessible to direct visualization. The ability of MRI to detect metastatic adenopathy is comparable to that of computed tomography (CT). The relationship of tumor to vessels and any intracranial extension can be assessed with a greater degree of accuracy than with contrast-enhanced CT. The multiplanar imaging capabilities of MRI are especially helpful in this regard. In regard to bone invasion, MRI provides a sensitive measure by depicting marrow involvement. However, destruction of cortical bone (such as that of the skull base) is more easily visualized, and best evaluated, by CT.

**Nasopharyngeal Carcinoma**

The clinical findings that may prompt suspicion of occult squamous cell carcinoma include palpable cervical lymph node metastasis (usually involving the deep cervical chain), nasal obstruction or epistaxis, cranial nerve symptoms (commonly from cranial nerves IX, X, XI, and XII and more unusually II, III, IV, and VI), and unilateral serous otitis media. Rarely, trismus (tonic spasm of the muscles of mastication) may occur after invasion of the pterygoid muscles.

The nasopharynx is a difficult area to examine clinically, and small lesions can easily be missed. Adults usually have a thin layer of adenoidal and mucosal tissue lining the posterior and lateral walls of the nasopharynx just superficial to the longus capitis and colli muscles and the pharyngeal constrictors. This tissue layer is slightly higher in signal intensity than the adjacent muscles on T1-weighted images and much higher in intensity on T2-weighted images. The signal characteristics of nasopharyngeal tumors are often similar to those of this band of tissue. Signs of early nasopharyngeal carcinoma include obliteration of the lateral pharyngeal recess (located posterior on axial images and superior on coronal images to the torus tubarius and orifice of the eustachian tube) and infiltration of the fat planes around the lateral tensor and medial levator palatini muscles, which mark the medial boundary of the parapharyngeal space. Subtle asymmetries of the superficial pharyngeal tissue layer are frequently identified in normal patients.

In more advanced cases, an obvious soft tissue mass may be seen in the nasopharynx, with possible extension into the parapharyngeal space fat (Fig. 8-1). Invasion of the skull base, cavernous sinus, foramen ovale, jugular foramen, carotid canal, maxillary, ethmoid, and sphenoid sinuses, nose, pterygopalatine fossa, and orbits should

**FIGURE 9–1. Squamous cell carcinoma of the nasopharynx. A, On the T2-weighted scan, a large soft tissue mass with intermediate signal intensity is noted in the posterior nasopharynx. The lesion extends anteriorly into the left nasal cavity. Retained secretions, with high signal intensity, are noted in the left maxillary sinus. B, On the precontrast T1-weighted scan, neoplastic tissue, retained secretions, and the normal turbinates are all intermediate signal intensity. C, After contrast administration, there is intense enhancement of the turbinates and the mucosal lining of the left maxillary sinus. Neoplastic tissue enhances but to a lesser degree, permitting differentiation.**
be assessed in every case. Displacement of the carotid artery and jugular vein is easily evaluated by MRI, especially with sagittal and coronal images. A flow void within vessels, even on a single imaging plane, reliably indicates vascular patency. However, vascular occlusion may at times be difficult to distinguish from flow-related artifacts. If vascular occlusion is suspected, there are many alternative imaging approaches that can resolve this question, including the use of phase images, gradient echo scans, two-dimensional time-of-flight magnetic resonance angiography (MRA), and contrast-enhanced MRA.

Bone destruction can be visualized on MRI, although attention to this aspect of image interpretation is important. Otherwise, significant lesions can be missed. Bone destruction appears as a replacement of the signal void from cortical bone (or cortical bone and air in the case of the petrous portion of the temporal bone) with intermediate- or high-signal-intensity soft tissue. Bone marrow–containing cancellous bone, such as the clivus, exhibits replacement of normal high-signal-intensity marrow fat with intermediate-signal-intensity material on T₁-weighted images. On T₁-weighted images, one may see intermediate- or high-signal-intensity material infiltrating the low-signal-intensity marrow, although T₁-weighted images are better for visualizing most cases of marrow invasion. MRI is usually adequate for assessing bony involvement, although CT may be necessary in some cases for evaluating fine bony detail. There is no doubt that MRI is superior to CT in assessing intracranial extension of tumor.

The nodal groups typically involved by nasopharyngeal carcinoma are the lateral retropharyngeal nodes (the node of Rouvière is the highest of these), the jugular group, including the jugulodigastric node, and the spinal accessory group in the posterior triangle deep to the sternocleidomastoid muscle. Imaging evaluation is especially important in the last group because these nodes are relatively inaccessible to clinical evaluation. Involvement of the upper cervical nodes is common, but mid- and lower cervical node metastases may also occur. Among all head and neck neoplasms, nasopharyngeal carcinoma has the highest incidence of contralateral nodal metastasis (up to 33% of cases). Metastatic lymph nodes tend to be of intermediate signal intensity and inflammatory involvement of high signal intensity on T₁-weighted scans. However, as in other parts of the body, whether a node is involved by tumor cannot be determined solely by its signal characteristics. Reliance must be placed on node size; a diameter of 1.0 to 1.5 cm (and greater) is considered suspicious. Use of size criteria for nodes carries a penalty in sensitivity and specificity. Microscopic involvement is missed, and post-infarct lymph nodes can be mistaken for metastatic disease. The larger and more numerous the nodes, the more likely they are to actually represent metastatic involvement. Necrosis within a node of any size, identified as a central area with signal intensity similar to fluid, identifies likely metastatic involvement.

Fluid in obstructed ethmoid and sphenoid sinuses and in the mastoid air cells resulting from obstruction of the eustachian tube can be recognized by its homogeneous appearance and very high intensity on T₂-weighted images (and low intensity on T₁-weighted images). Unusual, malignant lesions, such as esthesioneuroblastoma, lymphoma, rhabdomyosarcoma, and minor salivary gland tumors, cannot be distinguished by their MRI signal characteristics alone. In such cases, anatomic and clinical data, such as the origin of esthesioneuroblastoma in the upper nasal cavity and the occurrence of rhabdomyosarcoma in pediatric patients, are necessary in the differential diagnosis.

**Benign Lesions**

Inverted papilloma is an aggressive lesion that arises in the nares, expanding the nasal cavity and invading the adjacent maxillary and ethmoid sinuses. These lesions may recur after resection, and there is a known association with squamous cell carcinoma either at presentation or with recurrences. The signal characteristics of this lesion are nonspecific, and CT may help to assess the precise degree of bony destruction.

Nasopharyngeal (juvenile) angiofibroma (Fig. 9–2), the most common benign tumor of the nasopharynx, is seen in young male patients presenting with nasal obstruction or epistaxis. This tumor is thought to arise from the posterolateral wall of the nasal cavity and nasopharynx and may spread extensively via foramina and fissures of the skull base. Extension into the pterygopalatine fossa via the sphenopalatine foramen with anterior bowing of the posterior wall of the maxillary sinus is characteristic. There may be involvement of the sphenoid and ethmoid sinuses, infratemporal fossa, and orbit. Documentation of the extent of this lesion by axial imaging is crucial in management. In particular, intracranial extension greatly complicates surgical management and must be carefully evaluated. MRI is superior to CT in this regard because of the lack of artifact from dental fillings, the availability of high-resolution coronal and sagittal imaging, and the exquisite lesion contrast relative to the brain, extracranial fat, and muscle. This lesion may exhibit characteristic signal voids on MRI. This appearance, in association with clinical findings and typical anatomic involvement, can allow specific diagnosis in some cases by MRI. Nasopharyngeal angiofibromas exhibit marked enhancement after contrast administration, which helps evaluate the full extent of these infiltrating lesions. Noninvasive diagnosis is important because surgeons prefer not to biopsy these highly vascular masses.

Nasal polyps are hyperplastic lesions secondary to allergic stimuli. They may become large enough to deform the nasal septum. Antrochoanal polyps have a typical appearance, arising in the maxillary antrum and extending into the posterior nasopharyngeal airway. There may be an associated deformity of bone.

A not uncommon benign lesion occurring in the nasopharynx is Tornwaldt’s cyst, a well-defined, rounded structure in the midline of the posterior nasopharynx (Fig. 9–3). As is typical for a cystic lesion, Tornwaldt’s cyst displays very high, homogeneous signal intensity on T₂-weighted images.
FIGURE 9–2. Juvenile angiofibroma. A, On the T₂-weighted scan, a large soft tissue mass with intermediate signal intensity fills the nasal passages and nasopharynx. Inflammatory changes are noted in the maxillary sinuses bilaterally. On precontrast axial (B) and coronal (C) T₁-weighted scans, the mass is isointense with muscle. D, After contrast administration, there is intense lesion enhancement. Abnormal soft tissue expanding the right pterygopalatine fossa is well seen on the postcontrast scan. The borders of the lesion are also best delineated postcontrast.

FIGURE 9–3. Tornwaldt’s cyst. A small round lesion of increased signal intensity is identified in the midline in the posterior nasopharyngeal recess on the sagittal T₁-weighted image (A). No abnormal contrast enhancement was noted (image not shown). B, The cyst is hyperintense on the axial T₂-weighted scan. Tornwaldt’s cyst is a common incidental finding (4% incidence in autopsy series) occurring in the midline. The cyst arises from the notochordal remnant in the posterior nasopharyngeal vault and is lined by respiratory epithelium. Tornwaldt’s cysts are seen on magnetic resonance imaging as oval, well-circumscribed high-signal-intensity masses on T₁-weighted images. These lesions are usually of slightly increased signal intensity on T₁-weighted images, but the signal intensity can vary from hyperintense to hypointense.
Parapharyngeal Space

The parapharyngeal space is marginated by the pharyngobasilar fascia medially, the mandible and pterygoid muscles laterally, the prevertebral fascia posteriorly, and the pterygoid plates anteriorly. It may be further subdivided into prestyloid and poststyloid (or carotid sheath) spaces. Masses in this space may develop insidiously because this is a relatively silent area clinically. The most common lesions of this space include neural tumors (e.g., schwannomas and neurofibromas), paragangliomas (e.g., glomus jugulare and vagale tumors), and benign or malignant salivary gland tumors, which may arise from the deep portion of the parotid gland or from minor salivary glands in the parapharyngeal space. Less common lesions are lymphoma, metastases, congenital second bronchial cleft cysts, and mesenchymal tumors, such as lipoma, liposarcoma, rhabdomyosarcoma, hemangiomma, and hemangiopericytoma.

Diagnosis of glomus tumors is aided by knowledge of the typical areas where these tumors occur and their common appearance on MRI (Fig. 9–4). These lesions often exhibit characteristic foci of low signal intensity on both T₁- and T₂-weighted sequences. The signal intensity appearance is likely due to a combination of flow void from vessels and foci of fibrosis. These low-signal areas are easily seen on T₂-weighted images because they contrast with the high signal from the bulk of the tumor and from foci of flow-related enhancement in vessels. Glomus and neural tumors arise within the carotid sheath and tend to displace the carotid artery anteriorly and may displace the internal jugular vein posteriorly. Salivary gland tumors, arising in the prestyloid space, displace the carotid artery and jugular vein posteriorly.

Distinguishing between tumors of parotid and extraparotid origin in the prestyloid space is important for surgery. This may be accomplished by assessing the status of the parapharyngeal fat plane. If the fat plane is displaced medially or obliterated, tumor originating from the deep portion of the parotid is likely. If displaced laterally, clearly separating the lesion from the deep lobe of the parotid gland, an extraparotid origin may be assumed.

Infectious processes may extend into the parapharyngeal space from the petrous bone or tonsils. These are characterized by infiltration of the parapharyngeal tissue planes by intermediate- to high-signal-intensity material on T₁-weighted images. Frank abscess formation may be identified as a localized collection exhibiting the signal characteristics of fluid. Contrast administration (using a gadolinium chelate) is useful when infection is questioned. Abscess formation is simple to recognize postcontrast, with enhancement of a rim of tissue surrounding a nonenhancing necrotic center. In the setting of infection, the extent of surrounding inflammation is also clearly identified by abnormal contrast enhancement.

OROPHARYNX

Squamous Cell Carcinoma

This is the most common oral and oropharyngeal condition referred for MRI evaluation. Oropharyngeal carcinoma may be relatively occult clinically. It can present initially with referred pain distant to the oral cavity (e.g., otalgia) or with metastatic cervical adenopathy. More commonly, the lesion will be diagnosed by the referring clinician in the course of an evaluation of an oral mass or localized pain or by the dentist during a routine oral examination or an examination for ill-fitting dentures. An evaluation of the extent of disease may then be requested. Local submucosal invasion of lesions of the tongue, tongue base, and floor of the mouth may be quite deceiving clinically. MRI can accurately assess the degree of local involvement or midline spread, a very

Figure 9–4. Carotid body tumor. T₁- (A), precontrast T₁- (B), and postcontrast T₁-weighted (C) images reveal a large lesion in the right carotid sheath at the skull base. The tumor has inhomogeneous signal intensity on both T₁- and T₂-weighted images precontrast (to some extent the characteristic salt-and-pepper appearance) and demonstrates prominent enhancement. Glomus tumors, also called paragangliomas or chemodectomas, are slow growing, usually benign hypervascular neoplasms that arise from neural crest cell derivatives. In the head and neck region, common locations include the middle ear (glomus tympanicum), jugular fossa (glomus jugulare), inferior ganglion of the vagus nerve (glomus vagale), and carotid bifurcation (carotid body tumor). These tumors tend to contain a moderate amount of fibrous stroma separating a few large vascular channels. After contrast administration, enhancement is almost immediate with a slow washout.
important factor in deciding whether a lesion is resectable.

The likelihood of widespread disease depends on the anatomic site of origin of oropharyngeal carcinoma. More than 75% of lesions of the tonsillar regions and base of the tongue and more than 40% of lesions of the retromolar trigone and soft palate exhibit metastatic adenopathy at presentation. Adenopathy most commonly affects the submandibular and high anterior cervical chain, later extending to the middle and lower anterior cervical and posterior triangle nodes. Contralateral adenopathy is commonly seen (20%–30%), with lesions arising in midline structures, such as the soft palate and tongue base. Thus, imaging of oropharyngeal carcinoma has multiple roles similar to those in the nasopharynx: searching for an occult primary lesion, evaluating the extent of local invasion of a lesion diagnosed clinically, evaluating regional nodes, and assessing involvement of adjacent blood vessels.

MRI has a distinct advantage over CT in the evaluation of the oropharynx. The image is not as severely degraded by dental amalgam, although local field distortions may occur. The additional imaging planes offered by MRI can also be very useful in the oral cavity and oropharynx. Lesions of the tongue, floor of the mouth, and palate are often best defined in the coronal plane. The sagittal plane is the least useful for anatomic definition, although it may help in evaluating midline lesions.

The signal characteristics of oropharyngeal carcinoma are nonspecific: low or intermediate signal on T1-weighted and intermediate or high signal on T2-weighted images. Both types of images are necessary for complete evaluation. Oropharyngeal carcinoma may exhibit submucosal spread in all directions from the site of the primary tumor, and the precise extent of involvement must be assessed for the purposes of radiation or surgical therapy. Extensive invasion of the tongue is common with lesions of the tongue base and floor of the mouth, and the extent of tongue involvement is especially important for assessing the morbidity of surgical resection. Lesions of the retromolar trigone, palate, tonsil, and posterior oropharynx may extend into the pterygopalatine fossa, pterygoid muscles, and parapharyngeal space. Invasion of adjacent bony structures, such as the mandible, maxilla, and skull base, can be assessed by discontinuity of the cortical signal void and loss of the normal high signal of the marrow fat on T1-weighted images. The coronal plane is especially helpful in assessing bony involvement of the maxilla and skull base. Superficial tumor, as in the nasopharynx, may be impossible to identify or to differentiate from normal asymmetry, but this is not a serious limitation because it is usually apparent clinically.

Examination of the posttreatment patient is complicated by the resulting architectural distortion and fibrosis. CT has not shown great reliability in distinguishing fibrosis from recurrent tumor; MRI is superior in this regard. On T2-weighted images, recurrent tumor tends to have high signal intensity, whereas fibrosis is generally isointense with muscle. However, edema, infection, and inflammatory adenopathy may also demonstrate increased signal on T2-weighted images, reducing the specificity of this finding. Squamous cell carcinoma does demonstrate contrast enhancement after gadolinium chelate administration. This finding may also aid in distinguishing recurrent or residual tumor from scar. MRI performed 4 months or more after radiation therapy appears to be a reliable tool to differentiate residual tumor from scar tissue. Scar is generally hypointense on T1-weighted images and does not display enhancement as opposed to residual tumor, which is hyperintense on T1-weighted images and enhances after administration of a gadolinium chelate. Caution is indicated in image interpretation because signal changes and enhancement, resulting from postradiation changes alone, can persist for months after radiation therapy.

**Minor Salivary Gland Tumors**

The sublingual glands in the floor of the mouth rarely give rise to tumors, although 80% of those that do occur are malignant. The more common site of origin of oral salivary gland tumors is the minor salivary glands, scattered throughout the mouth and oropharynx but most numerous in the hard and soft palate. Approximately 40% of these tumors are benign (i.e., preponderantly of the benign mixed type), and 60% are malignant (i.e., adenoid cystic carcinoma, adenocarcinoma, and mucoepidermoid carcinoma are the most frequent types). Salivary gland tumors typically present as smooth, rounded masses without ulceration, unlike the ulcerated, exophytic appearance of typical squamous cell carcinomas. Although irregular local extension is characteristic of the malignant tumors, with the adenoid cystic variety typically invading along neural pathways, the benign and malignant types cannot be reliably distinguished on the basis of imaging alone. The MRI signal characteristics of all these tumors are nonspecific. Although these lesions tend to have a higher signal intensity than squamous cell carcinomas on T1-weighted images, there is a significant amount of overlap, and this differentiation cannot be made reliably on the basis of signal intensity alone.

**Miscellaneous Benign Lesions**

Benign cystic lesions of the mouth and oropharynx are commonly encountered, and MRI may be requested to evaluate their nature and extent. Cystic lesions may arise as a result of mucus extravasation from salivary ducts, from partial obstruction of salivary ducts with resulting cystic dilatation, from epithelial inclusions (i.e., lymphoepithelial cyst), or from cystic dilatation of thyroglossal duct remnants in the base of the tongue (i.e., thyroglossal duct cyst). All of these lesions may be expected to show the characteristic signs of cysts on MRI: low intensity on T1-weighted images and high intensity on T2-weighted images. However, high intensity on T1-weighted images can be seen if the fluid contents are hemorrhagic or proteinaceous, and very high, homogeneous signal intensity on T2-weighted images, on which cyst contents should equal the signal intensity of CSF.

A characteristic cystic lesion in the mouth is the ranula, which represents either a mucocele or mucus retention cyst of the sublingual glands (Fig. 9–5). The mucus
retention type, or simple ranula, presents as a smooth, fluctuant mass in the floor of the mouth and may be easily excised or marsupialized. The mucocele type, or plunging ranula, represents mucus extravasation from a sublingual duct and may exhibit extensive spread through the floor of the mouth to the submental area and even to the neck. Surgical treatment in this case is much more difficult, and MRI may help determine the extent of involvement of these lesions.

A variety of miscellaneous benign lesions may be seen. Lingual hemangiomas exhibit the signal characteristics of hemangiomas elsewhere in the body: low or intermediate signal intensity on T1-weighted and very high signal intensity on T2-weighted images (Fig. 9–6). Infections and abscesses in the tonsillar fossa or floor of the mouth show variable low intensity on T1-weighted images and high intensity on T2-weighted images depending on the degree of liquefaction.

MAJOR SALIVARY GLANDS

The major salivary glands include the parotid and submandibular glands. The sublingual glands were discussed with the oropharynx. By far, the leading indication for MRI examination of the major salivary glands is the evaluation of the location and extent of mass lesions. Chronic inflammatory diseases of the salivary glands remain the domain of sialography and, to a lesser extent, CT. Typically, slices 5 mm or less in thickness are obtained through the gland of interest. Although axial images usually supply most of the necessary information, coronal images often help in evaluating the salivary glands and surrounding structures.

Salivary tumors may arise in either the parotid or submandibular glands, although the most common site is the parotid. Three quarters of parotid tumors are benign, but submandibular tumors have an approximately 50% chance of malignancy. The majority of the benign tumors of the parotid gland and virtually all in the submandibular gland are pleomorphic adenomas (Fig. 9-7). The other significant benign tumor of the parotid is adenolymphoma or Warthin’s tumor. Multiplicity of masses favors Warthin’s tumor. The unusual, benign mesenchymal masses, lipomas and hemangiomas, exhibit characteristic MRI features as in other areas of the body. Lipomas show very high signal intensity on T1-weighted images and decreased signal on heavily T2-weighted images (isointense with fat). Hemangiomas exhibit very high signal on T2-weighted images, often with a characteristic multiseptated appearance.

The malignant masses include mucoepidermoid carcinoma, adenoid cystic carcinoma, adenocarcinoma, acinic cell tumors, squamous cell carcinoma, and the malignant variant of pleomorphic adenoma, malignant mixed tumors. These tumors are essentially indistinguishable by their MRI characteristics—intermediate intensity on T1-weighted images and high intensity on T2-weighted images—although pleomorphic adenomas are often quite low in signal intensity on T1-weighted sequences.
The contrast of these lesions with the surrounding gland varies with its histologic composition. The relatively greater fat content of the parotid gland gives it higher signal on T1-weighted images, often making parotid lesions easy to visualize on T1-weighted images as lower signal on T1-weighted images, often making parotid lesions easy to visualize on T1-weighted images as lower signal intensity masses (similar to muscle) relative to the surrounding gland parenchyma. Contrast enhancement will be nonspecific, although multiplicity of lesions or melanomas arising in these areas. The MRI appearance of tumors, including lymphoma, not uncommonly affect the parotid gland probably because of numerous intraparotid and periparotid lymph nodes. These nodes drain the face and scalp and are commonly affected by squamous cell carcinomas or melanomas arising in these areas. The MRI appearance will be nonspecific, although multiplicity of lesions is characteristic. Warthin’s tumor may also be multifocal and bilateral.

In the evaluation of parotid masses, it is crucial to assess whether the lesion involves the superficial or deep portions of the gland and the relationship of the facial nerve to the tumor, because these features dictate the surgical approach. The superficial and deep portions of the gland are separated by the intraparotid facial nerve, which courses anteriorly from the stylomastoid foramen and laterally to the retromandibular vein. Portions of the nerve may be more commonly seen with MRI than with CT, but even if the nerve is not visualized its relationship to a mass may be deduced from its expected course. Thin cuts angled 30 to 40 degrees caudal to the orbitomeatal line demonstrate the nerve with greater reliability.

Tumors that extend from the superficial to the deep portions of the gland characteristically exhibit a waistlike narrowing as they pass between the stylloid process and the mandibular condyle. It is important to assess whether deep masses originate in the parotid gland itself or in the parapharyngeal space. This distinction can usually be made on MRI by assessing the direction of displacement of the parapharyngeal fat plane: laterally in the case of parapharyngeal masses and medially in the case of deep parotid lesions. If the fat plane is obliterated, the determination cannot be made, but statistically a parotid origin is likely. The coronal plane often helps in evaluating this fat plane.

Although not a common primary indication for MRI of the salivary glands, inflammatory processes in the glands are important because they share the signal characteristics of tumors. They are usually more diffuse than tumors, but focal areas of inflammation or frank abscesses with irregular margins may mimic malignancy. Ductal ectasia may be seen secondary to ductal stenosis and calculus. Salivary duct calculi can be seen as foci of signal void on MRI but are much more reliably imaged with plain films, CT, or sialography. The parotid gland contains numerous lymph nodes. Normal, small nodes and enlarged, inflammatory nodes are commonly imaged during routine scans of the head and face and should not be mistaken for primary or metastatic tumors. The signal characteristics do not help this distinction, so caution must be exercised when small, nonpalpable masses are seen in or adjacent to the parotid gland. Occasionally, unilaterally or bilaterally hypertrophied masseter muscles are mistaken for parotid masses (on clinical exam). This distinction is easily made with MRI.

PARANASAL SINUSES

Benign Lesions

The high prevalence of incidentally discovered mucosal thickening in the sinuses is immediately evident to anyone beginning to interpret MRI scans of the head and face. This mucosal thickening exhibits very high signal intensity on T2-weighted images. It may be localized to a portion of one sinus or involve all of the sinuses and tends to be more extensive in pediatric patients. The clinical relevance of this finding is often obscure, and in most of these patients the finding is of no pathologic significance.

Another lesion that is often seen as an incidental finding is a sinus retention cyst (Fig. 9–8). These cysts are usually located in the inferior aspect of the maxillary antrum, exhibit smooth, rounded borders, and have low signal on T1-weighted images and characteristically very high signal on T2-weighted images, identical to fluid. Because retention cysts tend to occupy the most inferior portion of the maxillary antrum, the film reader may be misled to believe that there is sinus fluid on the basis of the lower axial cuts. However, on higher axial slices, sinus fluid will exhibit an air-fluid level, and retention...
Large round masses (retention cysts) are identified in the right and left maxillary sinuses on the axial T₁-weighted image (A). B, The parasagittal T₁-weighted image reveals the mass in the left maxillary sinus to be oval in shape with a broad base along the inferior surface of the sinus. Intense peripheral enhancement of the left maxillary sinus mass and subtle peripheral enhancement of the right maxillary sinus mass is seen on the axial T₁-weighted image postcontrast (C). Both masses are hyperintense on the axial T₂-weighted image (D). In clinical practice, incidental sinus disease such as that illustrated is common. It is critical, however, not to be distracted and thus potentially overlook significant accompanying disease. E, A second patient who, on first glance, has bilateral inflammatory sinus disease. Closer inspection of this T₂-weighted image, however, reveals a soft tissue mass (squamous cell carcinoma) with intermediate signal intensity invading the wall of the right maxillary sinus and sphenoid wing.
Air-fluid level. On sagittal (A) and axial precontrast (B) T₁-weighted images, abnormal soft tissue is noted in the posterior portion of the left maxillary sinus. There is also inflammatory sinus disease in the right maxillary sinus, which is incidental to the point of this case. The abnormality in the dependent portion of the left maxillary sinus demonstrates marked hyperintensity on the axial T₂-weighted image (C). It is important to note that the interface between air anteriorly and the lesion posteriorly is a level horizontal plane, given the patient's positioning in the magnet (supine). That this interface is horizontal, together with the signal characteristics on the T₂-weighted scan, defines the abnormality as an air-fluid level. The peripheral margins of this dependent fluid collection enhance on the axial T₁-weighted image postcontrast (D). An important pitfall in image interpretation is that a retention cyst can mimic the appearance of an air-fluid level when viewed in only one plane.

Cysts have a rounded upper margin. In questionable cases, sagittal views should resolve the issue (Fig. 9–9). Sinus polyps are a much less common lesion and may be indistinguishable from retention cysts, appearing as smooth, well-defined lesions exhibiting high signal intensity on T₁-weighted images. Mucoperiosteal thickening and inflammation of the mucosal lining enhance markedly after contrast administration (Fig. 9–10). Retained secretions within a cyst or an obstructed sinus do not enhance.

Air-fluid levels, seen in acute sinusitis, are well visualized by MRI, especially on T₂-weighted images, on which the high-signal-intensity fluid exhibits the greatest contrast with air. An exception is sinus hemorrhage. Depending on its age, blood may exhibit the highest signal on T₁-weighted images. This has been reported after trauma and in patients with a blood coagulopathy. The granulomatous diseases that may affect the sinuses, including Wegener's granulomatosis, midline granuloma, sarcoidosis, and tuberculosis, exhibit nonspecific soft tissue signal intensities within the sinuses and may show variable amounts of bone destruction. The degree of bone destruction, however, is more easily appreciated on CT.

Mucoceles (Fig. 9–11) are common cystic expansile lesions involving the paranasal sinuses. Approximately 60% occur in the frontal sinuses and 30% in the ethmoid sinuses; lesions are less common in the maxillary and sphenoid sinuses. The anterior ethmoid air cells are more frequently affected than the posterior ethmoid air cells. Mucoceles are benign slow-growing masses that develop secondary to obstruction of the sinus ostium. They are lined by secretory respiratory columnar epithelium. As the mucosa secretes mucoid fluid, the mass enlarges slowly, expanding and eroding adjacent bony structures. A history of sinus disease, allergies, or trauma is elicited in many of these patients. MRI demonstrates mucoceles as well-defined, expansile paranasal sinus lesions that have variable signal intensity depending on fluid content. Mucoceles can be hyperintense on both T₁- and T₂-weighted sequences, low signal intensity on T₁-weighted sequences, and high signal intensity on T₂-weighted sequences or low signal intensity on both T₁- and T₂-weighted sequences. Increased signal intensity on T₁-weighted images is usually due to the proteinaceous composition of the fluid, although the same appearance can be caused by hemorrhage. As a mucocele ages, the relative water content of the secretions decreases, resulting in increased protein content. Low-signal-intensity mucoceles have been reported with fungal infections, particularly allergic aspergillus sinusitis.

The variable signal characteristics of paranasal sinus mucoceles should not lead to confusion if greater emphasis is placed on the morphologic features of these lesions. The fibro-osseous lesions of the sinuses exhibit decreased signal on both T₁- and T₂-weighted images.
**Figure 9–10.** Mucosal membrane thickening. Abnormal hypointense soft tissue is seen along the periphery of the sphenoid sinus on sagittal (A) and axial (B) T1-weighted images. The posterior ethmoid air cells also contain abnormal hypointense soft tissue. This material is of marked hyperintensity on the axial T2-weighted image (C). Enhancement of the abnormal soft tissue is demonstrated on the axial T1-weighted image postcontrast (D). The mucosal thickening is best seen along the posterior wall of the sphenoid sinus; several small retention cysts are noted anteriorly.

**Figure 9–11.** Mucocele. A round low-signal-intensity expansile mass is identified within a posterior ethmoid air cell on pre- (A) and postcontrast (B) T1-weighted images. Peripheral enhancement of this mass is noted postcontrast (B). The lesion is of increased signal intensity on the T2-weighted exam (C).
They may have foci of signal void as a result of areas of dense calcification, which is much easier to appreciate on CT. The aggressive benign lesions of the nose and nasopharynx (e.g., inverted papilloma and juvenile angiomyofibroma) commonly involve the sinuses, especially the maxillary antrum.

**Malignant Lesions**

The most common malignant lesion of the paranasal sinuses is squamous cell carcinoma. The hallmark of this lesion on all imaging studies is opacification of a sinus, usually the maxillary antrum, by soft tissue with associated bone destruction. The theoretical advantage of CT in delineating bony detail has not proved to be a significant drawback to MRI for sinus carcinoma. With careful evaluation of the signal voids from cortical bone surrounding the sinuses, bone erosion can almost always be evaluated adequately.

MRI has several advantages over CT. It more easily distinguishes tumor from retained secretions within an obstructed sinus (Fig. 9–12). On T2-weighted images, retained secretions exhibit uniform very high signal intensity, which contrasts with the inhomogeneous, rela-
tively lower signal intensity of the tumor. Extension into surrounding spaces, such as the pterygopalatine fossa, infratemporal fossa, parapharyngeal space, and anterior and middle cranial fossae, is more easily evaluated by MRI. Coronal and sagittal T$_2$-weighted images are especially helpful in evaluating intracranial extension. T$_1$-weighted images are the most helpful in evaluating extension into fat-containing spaces, such as the pterygopalatine and infratemporal fossae and the parapharyngeal space. Axial images usually suffice in evaluating extension into these regions, but the coronal plane may be useful in assessing parapharyngeal space involvement.

Other rare malignancies of the paranasal sinuses include minor salivary gland tumors, rhabdomyosarcoma, plasmacytoma, and lymphoma. These tumors exhibit nonspecific findings on MRI, and the differential diagnosis depends on the patient’s age, presentation, and biopsy. Metastases may also involve the paranasal sinuses. The most common primary carcinoma to metastasize is renal cell carcinoma followed by lung and breast carcinoma. In general, the appearance of these lesions is nonspecific, but highly vascular metastases like renal cell carcinoma may exhibit areas of flow-related signal void.

**FACIAL SKELETON**

This discussion is limited to the osseous abnormalities of the facial skeleton, with special attention to the mandible and maxilla. Abnormalities of the paranasal sinuses and temporomandibular joints have been discussed in the appropriate sections. MRI can make a significant contribution to the study of abnormalities of the facial skeleton. Despite the ability of CT to define cortical bone precisely, many pathologic processes of bone predominantly affect the medullary cavity, with later destruction or thinning of the cortex. Most of the work on skeletal MRI has been done on the spine and extremities, and this experience has shown MRI to be much more sensitive to medullary abnormalities than CT. In addition, MRI better demonstrates extraosseous soft tissue extension. These principles can be extended to the examination of the facial skeleton.

The multiplanar capabilities of MRI are very useful in evaluating the complex spatial anatomy of the facial skeleton without requiring the patient to assume difficult or uncomfortable positions in the scanner. In addition to a routine initial sagittal scan to serve as a localizer, axial and coronal images are typically obtained. Although the axial images are usually best suited for evaluating the mandible, pathologic processes affecting the maxilla or zygoma may be better appreciated in the coronal plane. This is especially true of the palate, which may be quite difficult to evaluate in the axial plane because of partial volume effects. A slice thickness of 4 to 5 mm is adequate for evaluating most bony abnormalities.

As in other areas of the body, both heavily T$_1$- and T$_2$-weighted sequences are essential for evaluating the facial skeleton. Osseous abnormalities are often appreciated as areas of relatively lower signal intensity against the high-signal background of fatty bone marrow on T$_2$-weighted images. There is typically a reversal of the relative signal intensities of bone marrow and abnormality on T$_2$-weighted images as a result of the relatively high signal of most pathologic processes. This effect is especially important in children, who typically have a more erythropoietic marrow and in whom the normal bone marrow may be lower in signal intensity on T$_1$-weighted images, producing less contrast with bone marrow abnormalities. Extraosseous involvement of adjacent facial musculature is also better appreciated on T$_2$-weighted images, although the status of the surrounding fat planes is more easily seen on T$_1$-weighted images.

The main pathologic categories of the facial skeleton that can be suitably evaluated with MRI include cystic, neoplastic, and inflammatory lesions. Trauma and congenital abnormalities of the facial skeleton remain the province of radiography and CT, with the exception of frontoethmoidal encephalocele, which is easily evaluated by MRI.

**Cystic Lesions**

Cystic lesions are especially common in the maxilla and mandible. Those of radiologic interest are of two main types: fissural and odontogenic. Radicular cysts secondary to dental caries rarely require cross-sectional imaging techniques. Fissural cysts (e.g., nasoalveolar cyst, globulomaxillary cyst, and incisive canal cyst) arise in regions of embryonic sutures in the maxilla and mandible. Odontogenic or follicular cysts arise from primordial tooth follicles and may or may not contain a tooth remnant (dentigerous cysts). Occasionally, odontogenic cysts develop a keratinizing epithelial lining, in which case they are referred to as odontogenic keratocysts.

The appearances of these lesions are indistinguishable by MRI. They typically exhibit low or intermediate signal intensity on T$_1$-weighted images and very high signal intensity on T$_2$-weighted images. Rarely, these lesions may exhibit high signal intensity on T$_1$-weighted images as well, possibly caused by high protein content or hemorrhage within the cyst. MRI possesses no definite advantages over CT in evaluating cystic lesions of the maxilla and mandible. In fact, the superior delineation of cortical bone on CT may make it easier to define a continuous, expanded cortical rim, allowing the diagnosis of a nonaggressive lesion.

**Neoplastic Lesions**

The facial bones are subject to the same osseous neoplasms as bones elsewhere in the body, such as fibrosarcoma, osteosarcoma, chondrosarcoma, lymphoma, and plasmacytoma. Ewing’s sarcoma, metastatic tumors, eosinophilic granuloma, and giant cell tumor. In addition, the maxilla and mandible are subject to the unique ameloblastoma, a locally invasive tumor. In addition, the maxilla and mandible are subject to the unique ameloblastoma, a locally invasive tumor. In addition, the maxilla and mandible are subject to the unique ameloblastoma, a locally invasive tumor. These lesions exhibit the typical signal characteristics of tumors anywhere in the body: intermediate signal on T$_1$-weighted and increased signal on T$_2$-weighted images. These tumors typically exhibit the greatest contrast with normal bone marrow on T$_1$-weighted images. The margins of these lesions vary from well defined with indolent tumors to irregular and infiltrating with aggressive, malignant lesions. The
patterns of ossification and calcification within an osseous neoplasm are better appreciated on CT and radiography because of the poor sensitivity of MRI to calcium. Densely calcified and fibrotic areas may be seen as foci of decreased signal on both T₁-weighted and T₂-weighted images.

Inflammatory Lesions

Osteomyelitis, which usually arises from infected teeth, most commonly affects the mandible. It can also be seen in the bony margins of the sinuses, complicating sinusitis. The MRI appearance is nonspecific, with infiltrating, ill-defined low signal on T₁-weighted and high signal on T₂-weighted images. Disruption of cortical bone may be seen, although CT is more sensitive in this regard. However, edema of the surrounding soft tissues is better appreciated on T₂-weighted MRI images than on CT. Contrast enhancement can be extensive in the surrounding soft tissues and can thus assist in differential diagnosis.

NECK

The basic imaging protocol for the neck begins with a sagittal short TR/short TE sequence, which functions as a “scout” image. However, in the case of midline lesions, it may also supply useful additional information. At some clinical sites, with high-field instrumentation, this has been replaced by a fast spin echo T₂-weighted sagittal scan. Axial short TR/short TE and long TR/long TE sequences are then obtained through the area of interest. The slice thickness on axial scans should be 5 mm or less. To provide an additional anatomic perspective, a coronal short TR/short TE sequence may be added.

Lymph Nodes

The lymph nodes of the neck are grouped by location. These include submental, submandibular, anterior jugular (associated with the anterior jugular vein, superficial to the strap muscles), juxtavisceral (associated with the thyroid gland and tracheoesophageal groove), internal jugular, and posterior triangle (spinal accessory). The internal jugular chain is further subdivided into high, middle, and low regions using the levels of the carotid bifurcation and cricoid cartilage as dividing lines. Lymph nodes can be involved by metastatic disease from carcinoma of the head and neck or from distant sites, by lymphoma, or by inflammatory disease.

MRI is as accurate as CT in assessing cervical lymph nodes. Axial T₁-weighted scans, of all planes and sequences, are the most useful for evaluating the cervical nodes. T₂-weighted scans provide high spatial resolution and clear demarcation between the nodes and surrounding fat. Occasionally, coronal scans may provide additional anatomic information. T₂-weighted scans can be helpful in separating nodes from the adjacent musculature; lymph nodes are usually of higher signal intensity.

As with CT, the most reliable criterion for diagnosing pathologic lymph nodes is that of enlargement, a criterion that, unfortunately, has limitations in both sensitivity and specificity. A lymph node diameter of 1.0 cm or greater should be considered pathologic, with the exception of the submandibular and jugulodigastric regions, in which isolated nodes up to 1.5 cm in diameter may be normal. The jugulodigastric nodes are located at the point at which the posterior belly of the digastric muscle crosses the jugular vein, approximately at the junction of the high and middle internal jugular chains. Necrosis of any node, as indicated by fluid density on CT or fluid signal characteristics on MRI, should be considered pathologic. However, whether a particular pathologic node is involved by neoplastic or inflammatory disease cannot be assessed on the basis of imaging characteristics alone. Furthermore, microscopic nodal metastases remain beyond the reach of imaging diagnosis.

Primary head and neck tumors tend to metastasize to the submandibular, internal jugular, and posterior triangle chains. The most commonly involved site is the jugulodigastric node. In general, lesions of the oral cavity tend to spread to the submandibular, submental, and high to middle internal jugular chains, but lesions of the nasopharynx, hypopharynx, and supraglottic larynx may involve nodes at any level along the internal jugular chain and the posterior triangle nodes. Lesions of the tongue base and tonsillar fossa exhibit characteristics more like hypopharyngeal lesions than other lesions of the oral cavity. Nasopharyngeal carcinoma is noteworthy in having an especially high rate of bilateral nodal metastasis (>30%) and of metastatic disease at presentation (up to 90%), and imaging may play an important role in diagnosing the frequently occult primary lesion in the setting of cervical adenopathy.

Larynx and Hypopharynx

Low SNR, together with vascular and respiratory motion artifacts, has limited MRI of the larynx and hypopharynx. Newer coil technology, improved motion compensation techniques, and further decreases in scan time hold promise for improved imaging of this area. The submucosal fat planes throughout the hypopharynx and larynx are clearly depicted on T₁-weighted scans. The anatomic structures of the larynx and hypopharynx, including the epiglottis, laryngeal ventricle, true and false cords, and laryngeal skeleton, are clearly delineated with axial imaging. Additional imaging planes, such as the sagittal for evaluating the epiglottis and coronal for the glottis, can be helpful.

The true cords may be differentiated from the false cords on axial images using the same criteria as with CT. Unlike the false cords, the true cords do not have a submucosal fat plane on T₁-weighted images because they consist entirely of fibrous tissue and the vocalis muscles. The vocal process of the arytenoid cartilages is also a reliable marker of the true cords. The normal anterior commissure is less than 2 mm thick.

The laryngeal skeleton has a variable appearance on MRI images, depending on the state of ossification of the cartilages. In young patients, before significant ossification develops, the laryngeal cartilage exhibits inter-
mediate signal intensity on both T1-weighted and T2-weighted scans. As calcification develops, foci of signal void can be seen, and once ossification is complete, a well-defined cortex with fatty marrow can be appreciated. Calcification and ossification of the cartilages occur in an irregular, although more or less symmetrical, pattern, which can make assessment of cartilage destruction problematic.

MRI has shown promise in evaluating squamous cell carcinoma and other lesions of the larynx. As with CT, the primary role of MRI in this disease is assessing submucosal extension before surgery or radiation. Of all scan techniques, T1-weighted sequences are often the most useful because of the high contrast between the intermediate signal tumor and high signal submucosal fat. In addition, T1-weighted scans tend to be less degraded by motion artifacts and to have higher SNR. T1-weighted scans are also more sensitive for detecting enlarged cervical lymph nodes. T2-weighted images should be obtained as an adjunct because they may help delineate relatively high-signal-intensity tumor from the surrounding normal musculature. Both T1-weighted and T2-weighted scans need to be carefully examined to assess involvement of the laryngeal skeleton. Even so, definitive assessment may be impossible in the presence of irregularly calcified or ossified cartilages.

MRI can help in evaluating the postoperative or post-radiation patient. On T2-weighted images, posttreatment fibrosis tends to be very low in signal intensity, with recurrent tumor of intermediate or high signal intensity. Areas of recurrent tumor may exhibit enhancement after contrast administration (using a gadolinium chelate).

Thyroid and Parathyroid

The role of MRI in evaluating parathyroid lesions has been investigated in several reports. Parathyroid adenomas characteristically exhibit high signal intensity on T2-weighted images. This and their typical location posterior to the lobes of the thyroid gland (or ectopically in the superior anterior mediastinum) allow recognition. They exhibit intermediate signal intensity on T1-weighted images, allowing differentiation from cystic lesions. Although high-resolution ultrasonography can detect adenomas, it is quite limited for evaluating postoperative patients and those with ectopic parathyroid glands. MRI may make significant contributions in the evaluation of hyperparathyroidism. However, high-resolution MRI scans with excellent SNR is required for the evaluation of these small lesions on T1-weighted images.

Imaging of the thyroid gland currently is performed with high-resolution ultrasonography and nuclear medicine techniques. These are usually sufficient for the routine evaluation of benign thyroid disease. Nevertheless, benign thyroid lesions are quite common and are often seen on neck images obtained for other indications. The normal thyroid gland is of intermediate signal intensity on T1-weighted scans and mildly hyperintense on T2-weighted scans. Thyroid adenomas may exhibit slightly decreased intensity on T1-weighted sequences and markedly increased intensity on T2-weighted images. Cystic areas show marked hypointensity on T1-weighted images and even greater hyperintensity on T2-weighted images. If hemorrhage is present in the lesion, it may be hyperintense on T1-weighted sequences. A multinodular goiter is visualized as an enlarged thyroid with lobulated contours and heterogeneous signal intensity on all imaging sequences, depending on the ratio of normal to adenomatous and cystic areas.

Thyroid carcinoma is indistinguishable from benign disease based on signal characteristics alone. Local invasion, nodal metastases, and vascular involvement can be detected. MRI may have a role in evaluating postoperative recurrence because there is evidence that postoperative fibrosis may be detectable based on its low signal intensity on T1-weighted images compared with the higher signal intensity of recurrent tumor.

Miscellaneous Lesions

The role of MRI in disorders of the neck other than carcinoma and lymphadenopathy has not been widely evaluated. Cystic lesions exhibit typical fluid characteristics—homogeneous, low signal on T1-weighted and very high signal on T2-weighted images—allowing easy recognition. Complex cysts, such as those containing hemorrhagic, proteinaceous, or infected fluid, may have unusual signal characteristics, most commonly intermediate or high signal on T1-weighted images. Branchial cleft cysts, thyroglossal duct cysts, and cystic hygromas may be differentiated by their characteristic locations in the anterior triangle, midline, and posterior triangle, respectively. Cystic hygromas also typically exhibit a more infiltrative growth pattern with multiple septions. Hemangiomas and other mesenchymal tumors show the same MRI appearances as in other areas of the body. Infection demonstrates infiltration of fat and muscle planes with foci of fluid signal intensity corresponding to liquefaction and abscess formation.

The carotid artery and jugular vein are clearly visualized on axial images. Partial volume effects can limit depiction on coronal and sagittal images. The presence of flow void within these vessels on spin echo images is diagnostic of patency, but various flow-related artifacts, such as inflow enhancement and even echo rephasing, may make the interpretation of intraluminal signal problematic. Single-slice gradient echo techniques (two-dimensional time of flight), which produce a bright signal from flowing blood, frequently help in this situation. Arteriovenous malformations can be identified as complexes of vessels with predominant signal voids on spin echo images but with varying degrees of intraluminal signal as a result of foci of thrombosis and flow-related artifact. Gradient echo images clearly demonstrate the patent vessels.