Skin and Soft-Tissue Lesions
Bradley N. Delman, Jane L. Weissman, and Peter M. Som

INTRODUCTION

SKIN AND SUBCUTANEOUS LESIONS

Scar
Hypertrophic Scar
Keloid
Epidermoid Cyst (Sebaceous Cyst)
Pilomatrixoma
Basal Cell Carcinoma
Squamous Cell Carcinoma of the Skin
Melanoma
Merkel Cell Tumor
Skin Metastasis
Subcutaneous Fat Necrosis of the Newborn
Sclerema Neonatorum
Plexiform Neurofibroma and Skin Neurofibromas
Silicon Augmentation
Alloderm Augmentation

FAT-CONTAINING LESIONS

Ordinary Lipoma
Infiltrative (Intramuscular) Lipoma
Madelung’s Disease
Liposarcoma

INTERSTITIAL LESIONS

Fibrosarcoma
Benign Fibrous Lesions (Fibromatoses)
Desmoid Tumor
Congenital Fibromatosis (Generalized and Localized)
Nodular Fasciitis (Pseudotumor of the Skin)
Proliferative Fasciitis
Necrotizing Fasciitis

MUSCLE-RELATED LESIONS

Levator Claviculae Muscle
Denvervation Atrophy

Muscle Hypertrophy
Fibromatosus Collis (Sternomastoid or Sternocleidomastoid Tumor)
Muscular Torticollis
Myositis
Myositis Ossificans
Muscular Dystrophies
Myotonic Dystrophy
Rhabdomyosarcoma
Metastasis to Muscle

THE STYLOHYOID SYNDROMES

Eagle’s Syndrome
Styloid Carotodynia
Hyoid Fasciitis

BLOOD VESSELS AND VASCULAR VARIATIONS

Veins
Asymmetry of the Internal Jugular Veins
Multiple Jugular Veins
Phlebectasia
Thrombosis
Pseudocollateral and Collateral Veins
Condylar Vein
Arteries
Medial Deviation of the Carotid Artery
Aberrant Retroesophageal Right Subclavian Artery
Thrombosis and Dissection
Aneurysm
Hemangioma
Hemangiopericytoma

PERIPHERAL NERVE SHEATH TUMORS

Zenker’s Diverticulum
Dilated/Obstructed Cervical Esophagus
INTRODUCTION

There are a variety of skin and soft-tissue lesions in the head and neck with manifestations that can be seen on CT and MR imaging. Although overall there are a large number of such lesions, this chapter will address only some of the more common ones and discuss pertinent differential diagnoses.

SKIN AND SUBCUTANEOUS LESIONS

The skin (integument, cutis) is largely ignored on CT and MR imaging. In this section, the skin (epidermis, dermis, and the skin appendages including the pilosebaceous units [hair, sebaceous and apocrine glands, and associated smooth muscle fascicles]) and the immediate subcutaneous tissues are considered.

Diffuse thickening of the skin is most commonly seen in edematous and inflammatory conditions. However, diffuse skin thickening can also be seen after irradiation or, rarely, with tumor infiltration. Almost always, there is associated thickening of the subcutaneous fat and injection of this fat with a rete-type pattern of soft tissue representing dilated lymphatic and vascular capillaries and venules. In addition, after trauma there can be subcutaneous hemorrhage and hematoma (Figs. 41-1 to 41-3). When clinical and imaging distinction between these entities is difficult, serial imaging may offer increased specificity: hematomas tend to show evolution and resolution; there is relative stability or improvement with radiation changes; and tumors may progress to variable degrees, depending on their histology and aggressiveness. Phlegmon, a collection of watery fluid within the interstitial tissues and spaces of the neck, is usually associated with an acute suppurative inflammation.
Cellulitis can be seen with simple phlegmon or abscess, with an abscess distinguished from phlegmon by the presence of an enhancing rim (Fig. 41-1B). Further examples of these changes can be seen throughout other sections in this book.

**Scar**

Scar formation occurs whenever there has been an ulceration or laceration of the skin. The type of scar often reflects the pattern of healing; thus, a scar may be flat, hypertrophic, or atrophic. It may also be firm or, as a result of collagen proliferation, hard. The skin appendages and skin lines are usually lost within the scar bed. On imaging, scars may vary significantly in appearance. The routine flat scar may not be clearly seen, so the only clue to the surgical line may be an infolding of the skin. Conversely, there may be an obvious skin thickening, often in conjunction with subcutaneous scar extending almost as deeply as the muscle line (Fig. 41-4).

**Hypertrophic Scar**

A hypertrophic scar usually develops when wound margins are placed under tension. The clinical features distinguishing hypertrophic scars from keloids include the observation that hypertrophic scars remain confined to the original scar line, and with time they tend to flatten out or regress spontaneously. Histologically, they lack hyalinized collagen bundles, and they contain little or no mucinous ground substance. Fibroblasts and foreign body granulomas are also common. Like keloids, these lesions have a higher water content than normal scar and skin, although the water content tends to diminish as the scars age. While distinction from keloids may prove difficult by CT, studies on resected tissue have shown that the T1-weighted signal intensity of hypertrophic scar tends to reach normal levels within 1 to 2 years, unlike keloid, in which the T1-weighted signal intensity may take 10 years to normalize. Treatment of hypertrophic scars is similar to that of keloids, but only about 10% of hypertrophic scars recur.

**Keloid**

Keloids are benign overgrowths of dermal scar tissue that usually develop after local trauma, although sometimes there has been no identifiable insult. They are more common in dark-skinned individuals and in people with blood group A, and a family history may be present. Their growth may be accelerated by pregnancy and puberty. Keloids are slightly more common in women, and most arise in people between 10 and 30 years of age, probably due to the higher incidence of trauma and acne in this age group. About 70% of postsurgical keloids develop within 6 months of surgery, but up to 17% may appear one year or more after surgery. Most keloids are significant only because of their cosmetic nature, although some may be associated with pruritis, pain, and/or paresthesias. Despite the fact that their borders are usually well demarcated, they tend to be irregular in outline. Keloids usually grow outward from the original scar line and extend into adjacent tissues. On imaging, they are bulky soft-tissue masses that project away from the skin line. Histologically, keloids are composed of thick, glassy, eosinophilic or hyalinized bundles of collagen, often associated with abundant mucinous ground substance. The bulky overgrowth of tissue may reflect an attempt to duplicate the tensile strength of normal skin within this disordered collagen-containing scar tissue.
keloids includes excision, irradiation, and injection with corticosteroids, although up to 63% may recur after treatment.

**Epidermoid Cyst (Sebaceous Cyst)**

The epidermoid cyst—the commonly used term sebaceous cyst is a misnomer—is the result of the proliferation of surface epidermoid cells within the dermis. The lining of many nontraumatic cysts is believed to be derived from the follicular infundibulum, as these cysts commonly develop from the occlusion of pilosebaceous follicles. Less common causes include the implantation of epidermal cells into the dermis secondary to a penetrating injury and the trapping of epidermal cells along the lines of embryonal fusion planes. These cysts are rare in children but common in adults, and patients with basal cell nevoid syndrome may have numerous lesions. On imaging, these cysts are ovoid in shape, with a noninfiltrating rim. The superficial margin of the cyst usually touches the deep skin line, and the cyst is filled with mucoid attenuation material and scattered dystrophic calcifications (Fig. 41-6).

These cysts are usually slowly growing, painless masses that elevate the skin and often have a central punctum that represents the plugged orifice of the pilosebaceous follicle. The cysts are filled with cheesy, keratinous yellow-white material. They may become infected; uncommonly, they may rupture, causing a foreign body reaction.

The differential diagnosis includes pilar cyst of the scalp and face and steatocyst simplex. Steatocysts are often confused with epidermoid cysts, although steatocysts can be distinguished by the yellow, oily fluid that they contain.

**Pilomatrixoma**

Pilomatrixoma, or calcifying epithelioma of Malherbe, is an uncommon benign neoplasm of hair follicle origin. These neoplasms favor the hair-bearing areas, and approximately half of the reported tumors have been in the head and neck region. The majority of cases have been reported in patients in their first two decades of life; however, there is a second peak of occurrence in older patients. Overall, there is a female predominance.

Histopathologically, there are hair matrix–like basaloid cells and shadow or ghost cells, which have a central unstained area that represents a shadow of a lost nucleus. Intracellular and stromal calcification is reported in about 70% of cases, and tumors with large areas or nests of shadow cells proportionally have increased calcium deposition. It has been suggested that osteopontin, a protein marker associated with bone production, may be produced by macrophages and play a role in the deposition of calcium phosphate in the shadow cell nests.

The typical patient presents with an asymptomatic, superficial, solitary, firm mass that is located either within the dermis or in the subcutaneous fat, with tethering to the dermis. The overlying skin often has a reddish-blue discoloration. Even though these tumors usually grow slowly (months to years), excision is usually recommended to avoid a foreign body reaction, associated inflammation, and resulting scar formation. Complete surgical excision is
Multiple tumors account for 2% to 3.5% of reported cases, and there have been reported rare associations with myotonic muscular dystrophy, Gardner’s syndrome, sarcomatous, and skull dysostosis. A rare familial occurrence not associated with other syndromes has also been reported.5

On CT, the lesion appears as a noninfiltrating mass in the subcutaneous fat with varying degrees of focal calcification. There is no significant enhancement with iodinated contrast. The tumor margin cannot be separated from the epidermis; hence, the mass appears contiguous with the overlying skin. There is no extension into the underlying musculature (Fig. 41-7). Pilomatrixomas have a variable appearance on MR imaging, ranging from intermediate to slightly hyperintense on T1-weighted images and slightly hypointense to slightly hyperintense on T2-weighted images. One report suggests that bands of increased T2-weighted signal intensity seen extending from the periphery of the lesion to its center may represent basaloid sheets identified histologically.6 No gadolinium enhancement has been described. On ultrasound, this well-defined lesion is typically hyperechoic centrally, with a thin hyperechoic rim; distal shadowing from calcifications is common.7

The differential diagnosis includes sebaceous cyst, foreign body reaction, ossifying hematoma, giant cell tumor, chondroma, dermoid cyst, degenerating fibroxanthoma, metastatic bone formation, and osteoma cutis. The very rare malignant counterpart of the pilomatrixoma is the pilomatrix carcinoma, which is characterized by vascular and muscle invasion as well as local recurrence following resection. Distant metastases are uncommon but have been reported. The differential diagnosis of this malignancy includes basal cell carcinoma with matrical differentiation, matricoma, and metastasis.5 Proliferating trichilemmal tumors, which may appear similar to invasive pilomatrixomas, are instead likely to arise from trichilemmal cysts that have been exposed to trauma or inflammation.9
Basal Cell Carcinoma

Basal cell carcinoma is the most common type of skin carcinoma. It is more common in males and rarely occurs in dark-skinned people or Asians. The increased incidence in individuals with light hair, light skin, inability to tan, and prolonged sun exposure has long implicated actinic damage in the pathway of basal cell carcinoma development. In addition, patients who have basal cell carcinoma are three times more likely than the normal population to develop another UV-related malignancy, melanoma. Basal cell carcinomas tend to occur in the central midface. Prognostically, these tumors tend to be more aggressive than basal cell tumors at other head and neck sites.

After tumor site, histologic type is the most important factor in determining the prognosis. Overall, basal cell carcinomas rarely metastasize (0.1%), but tumors with squamous differentiation and/or an adenoid pattern occurring about the orbits have the highest incidence of metastasis. Perineural, lymphatic, and vascular-type metastasis can occur, and once metastasis has developed, the average survival is only 1 to 2 years. Histologic analysis shows that basal cell carcinomas grow into the dermis as cords, strands, and sheets of small basloid cells; centrilobular necrosis is not uncommon. Surgery is the treatment of choice.

On imaging, basal cell carcinomas have a variable appearance, depending on the size of the tumor at the time of imaging. When small, they are soft-tissue masses in the skin line, usually with deep extension into the subcutaneous tissues (Fig. 41-8). When large, they appear as deeply infiltrating soft-tissue masses. Basal cell and squamous cell carcinomas can be difficult to distinguish by imaging.

Squamous Cell Carcinoma of the Skin

Squamous cell carcinoma of the skin commonly occurs in the head and neck. These tumors can arise de novo or in preexisting lesions such as actinic keratosis or squamous cell carcinoma in situ (Bowen’s disease). There is a high incidence of squamous cell carcinomas in patients with hereditary skin diseases such as oculocutaneous albinism or xeroderma pigmentosum. Men are more commonly affected than women (2:1), and most tumors arise in the sixth and seventh decades of life. Histologically, these are neoplasms of keratinocytes in the surface epidermis or in the epithelium of adnexal structures. Tumor typically penetrates the reticular dermis. The incidence of metastasis varies from 5% to 30%. Although metastasis is rare, it can occur, with a median survival of about 5 years. Patients with high-risk features such as tumors larger than 2 cm or those that have invaded the underlying tissue have a higher risk of metastasis.

Squamous cell carcinoma of the skin can be managed with surgery, radiation therapy, or a combination of both. Intralesional injection of 5-fluorouracil or a topical chemotherapeutic agent, such as 5-Fluorouracil cream, may be used for smaller tumors. Immunotherapy, such as with interferons, can also be considered.

Secondary findings such as adenopathy favor the latter. Basal cell nevoid syndrome (Gorlin syndrome, Gorlin-Goltz syndrome) is an autosomal dominant disorder in which patients develop multiple basal cell carcinomas (especially at a young age), odontogenic keratocysts, palmar and plantar pits, and skeletal abnormalities. Associations with many other benign and malignant tumors have also been reported. Other conditions in which relatively young patients develop basal cell carcinomas include xeroderma pigmentosum and nevus sebaceous.
Melanoma

Melanoma is a highly malignant tumor of melanocytes derived from the neural crest. The primary factor associated with the development of melanoma is excessive exposure to UV radiation, so patients with benign (melanocytic) nevi, freckles, dysplastic nevi, and a history of three or more severe sunburns are all at increased risk. Lymphoscintigraphy has proven useful in defining drainage pathways and suggesting which nodes are most likely to harbor metastatic deposits. Approximately one fourth of supraclavicular cutaneous melanomas arise on the neck; the second most common site is behind the scalp (36%); less frequent sites include the face (22%) and ear (14%).

Numerous studies indicate that females have a better prognosis than males, possibly due to earlier detection and treatment. A possible increase in melanoma progression due to pregnancy and female hormone replacement therapy has recently been disproven. Factors associated with improved survival include age less than 60 years and thinner lesions with less invasion. The 10-year survival rate has been reported as high as 70% in males and almost 90% in females, although most studies report an overall 5-year survival rate of about 70%. Approximately 15% of patients die from their melanoma, and only 5% of patients with metastatic melanoma remain recurrence free for the remainder of their lives. Mucosal melanomas are also associated with significant morbidity; these are discussed in Chapter 6.

Merkel Cell Tumor

Merkel cell tumor (trabecular carcinoma, cutaneous small cell undifferentiated carcinoma, primary neuroendocrine carcinoma) is an undifferentiated tumor of the skin, which in the elderly may clinically mimic a basal cell carcinoma. The typical patient is Caucasian and above 50 years of age. As in melanoma, a neural crest origin is suspected. Approximately 25% of patients also develop squamous cell carcinoma in the same region, either separately or interspersed within the Merkel tumor itself. Overall, the incidence correlates with sun exposure, and the head and neck region may account for two thirds of all cases, although the extremities and buttocks are also frequent sites. Patients with B-cell malignancies who have undergone organ transplantation are also at increased risk. The Merkel cell tumor is usually identified as a slow growing nodule. The vast majority of patients present with localized skin lesions and no nodal disease. However, these are aggressive tumors and should be treated by wide surgical excision. Median survival is 29 months, with evidence that radiotherapy improves absolute 5-year survival (38% vs. 27%). Local recurrence occurs in about a third of patients, while nodal metastases are seen in 50% and visceral metastases in 15%.

Skin Metastasis

Metastasis to the skin has been reported from a number of primary head and neck tumors, as well as from most of the common primary neoplasms arising below the clavicles. In all cases, such metastases carry an associated dire prognosis. On imaging, the skin line soft-tissue mass is similar in appearance to a basal cell or squamous cell carcinoma (Fig. 41-10). Tumor implantation has also been reported about the tracts of drains placed during resection of numerous malignancies.

Subcutaneous Fat Necrosis of the Newborn

Subcutaneous fat necrosis of the newborn (SCFN) is a condition affecting full or postterm infants, starting days to weeks after a complicated perinatal period. It is characterized by the appearance of one or more well-defined.
non-suppurative, erythematous or violaceous, mobile subcutaneous masses, often with taut overlying skin. There is usually a history of obstetric manipulation, perinatal asphyxia, meconium aspiration, or maternal disease. The typical lesions develop on the shoulders, back, buttocks, thighs, and cheeks. It has been postulated that these lesions result from localized tissue hypoxia and mechanical pressure, which further compromises the local circulation. It has also been suggested that thrombocytosis may play a role in the pathogenesis of adipose tissue necrosis by reducing blood perfusion, leading to relative hypoxia and hypothermia. The nodules of SCFN may enlarge for several weeks to months but then usually involute. Rare local complications include epidermal atrophy, ulceration, scarring, or infection. Pathologically, SCFN is characterized by clusters of adipocytes, histiocytes, fibroblasts, scant lymphocytes, and numerous foreign body giant cells. Granulomatous fat necrosis and calcifications are seen. Hypercalcemia is the most serious complication associated with SCFN; it is believed to be caused by an excess production of 1,25-dihydroxyvitamin D by the granulomatous macrophages. Because hypercalcemia may occur anytime from 1 to 6 months after the skin lesions first develop, these neonates should have calcium levels monitored for at least 6 months. The radiologist should monitor for possible renal complications of hypercalcemia, and renal ultrasonography is recommended to exclude nephrocalcinosis and nephrolithiasis. Other clinical associations with hypercalcemia include hypotonia, vomiting, anorexia, irritability, and failure to thrive.

On CT, the lesions of SCFN appear localized to the subcutaneous tissues immediately deep to the skin. The nodules may have minimally infiltrative margins and areas of central low density only slightly higher in attenuation than that of fat. The nodules may partially obliterate the fat planes over the superficial margin of an adjacent deep muscle; however, the muscle itself and the deeper fat planes about the muscle are normal. There also may be a diffuse subcutaneous fullness with increased attenuation in the fat, without a discrete mass (Fig. 41-11). Linear or sheet-like areas of diminished signal are typically seen on both T1-weighted and T2-weighted images, although increased signal intensity may also be noted on T2-weighted images. Findings are even more conspicuous on fat-suppressed, inversion recovery sequences, where involved areas appear bright.

If the clinical situation warrants, fine needle aspiration of the subcutaneous lesions may be useful to confirm the diagnosis. The finding highly suggestive of SCFN is negatively stained, needle-shaped crystals within histiocytes and multinucleated giant cells. The main reason to establish the diagnosis of this self-limiting entity is to differentiate it from other lesions that may require surgery. The principal clinical differential diagnosis includes other histologically distinct soft-tissue lesions of infancy such as rhabdomyosarcoma, the spectrum of fibrous lesions, hemangioma, neurofibromatosis, and sclerema neonatorum.

**Sclerema Neonatorum**

Sclerema neonatorum is a rare disease of the newborn that is characterized by a diffuse hardening of the subcutaneous adipose tissues. As such, it is distinct from the localized lesions of SCFN. Sclerema appears within the first postnatal week in neonates who are severely ill with pneumonia, peritonitis, or other infectious or congenital diseases. Premature infants are particularly susceptible, and the prognosis is grave. Sclerema may represent a disorder of lipolysis. Histologic analysis has demonstrated subcutaneous fibrosis in all patients, with most having chronic dermal inflammation, epidermal thinning, and hypercollagenization of the dermis.

**Plexiform Neurofibroma and Skin Neurofibromas**

The presence of a plexiform neurofibroma is sufficient to warrant the diagnosis of von Recklinghausen’s disease even in the absence of other associated stigmata. A plexiform lesion can be seen as a fusiform or nodular mass, or as a tortuous enlargement of nerves that has been described as a ‘‘giant nerve’’ or ‘‘bag of worms.’’ In the head and neck, these lesions are often seen in the subcutaneous tissues (Fig. 41-12). The degree and pattern of calcification vary.

Another manifestation of neurofibromatosis is the presence of multiple neurofibromas on the skin, in addition to neurofibromas within the neck and facial region (Fig. 41-13). A discussion of both neurofibromas and schwannomas also appears in Chapter 6.

**Silicon Augmentation**

Silicon and silicon products have long been used as tissue expanders and for cosmetic surgery. Historically, silicon had been injected subcutaneously to fill skin depressions. Unfortunately, free silicon often invades a granulomatous and fibrotic reaction that ultimately causes further deformity.

**FIGURE 41-11** Axial CT scan shows a partially infiltrative-appearing subcutaneous soft-tissue mass (arrows) in each side of the face. This newborn had subcutaneous fat necrosis.
FIGURE 41-12 Axial contrast-enhanced CT scan shows multiple masses primarily in the right neck of this patient with neurofibromatosis. Some of the masses are partially cystic. In addition, in the subcutaneous right face there is a nodular, poorly defined soft-tissue mass with a few scattered calcifications (arrow) representing a plexiform neurofibroma.

FIGURE 41-13 Coronal T1-weighted, fat-suppressed, contrast-enhanced MR image (A) shows an enhancing left hypopharyngeal neurofibroma and multiple small, enhancing skin neurofibromas. Axial T2-weighted MR image (B) shows the same hypopharyngeal neurofibroma and the innumerable skin neurofibromas. Axial T1-weighted, fat-suppressed, contrast-enhanced MR image (C) on another patient shows neurofibromas in the right supraclavicular fossa, the right back soft tissues, and the anterior left neck. In addition, there are multiple skin neurofibromas.
of the overlying skin. On imaging, one sees thickening of the overlying skin, soft-tissue nodularity within the subcutaneous tissues, and scattered radiodensities (silicon) within this process (Fig. 41-14). If the fibrotic and granulomatous reactions are severe enough, there is considerable deformity of the skin contour. Silicon products are less frequently implanted today, and when used, they are encased in containers that cause little reaction in the adjacent soft tissues.

**Alloderm Augmentation**

Numerous materials, both autologous and nonautologous, have been used for augmentation of soft-tissue defects in the facial region. There is no ideal material for soft-tissue augmentation, as each material has its limitations. AlloDerm dermal graft (LifeCell Corporation, Branchburg, NJ) combines the benefits of autografts and allografts. There is a very low incidence of complications such as rejection, mobilization, absorption, dislocation, or extrusion. In addition, the use of Alloderm minimizes two surgical problems: donor site morbidity and lack of adequate tissue for reconstruction. Alloderm has been shown to be useful in facial plastic procedures and the repair of burn injuries. On CT, Alloderm is of a fairly high attenuation, being greater than that of muscle but less than that of bone (Fig. 41-15). On MR imaging, if seen, it usually has a low-intermediate signal intensity on all sequences.

**Foreign Bodies**

In addition to surgically placed materials, foreign bodies may be identified following perforation or laceration. Overall, perforations are uncommon, and their major manifestations arise deep to the skin and subcutaneous tissues. Most foreign bodies in the neck are ingested and, after perforating the mucosa, migrate outside the pharynx or cervical esophagus. Oral cavity or oropharynx perforations (especially those involving the tonsillar pillars) are not uncommon in young children, who tend to walk, run, and fall with objects in their mouths; care must also be taken to exclude carotid injury. Finally, penetrating injuries from bullets, wires, knives, and other objects can result in retained foreign bodies. Focal lucency within soft tissues immediately following penetrating trauma often represents gas; however, hypodense foreign bodies made of plastic, glass, or wood can appear similar. While the density of many of these bodies may not change over time, that of rehydrated wood may gradually approach soft-tissue density. Gas may also be generated by certain bacteria in infected wounds. If not removed, foreign objects can cause abscess or pseudaneurysm formation, or the foreign body can migrate into the chest, spine, or even intracranially.

In recent decades, the dietary preferences of many people have changed to favor more fish and fowl and less meat. The bones of chickens, quails, and so on are fairly large and well ossified, making identification on either plain films or CT...
routine. However, special mention of the radiology of fish bones is warranted. Several studies have shown that CT examination identifies almost all types of fish bones, whereas plain films often fail to identify some varieties. Factors that affect the imaging identification of fish bones include the radiodensity of the fish bone, the orientation of the bone in relation to the imaging plane, and the location of the bone (e.g., tonsil, hypopharynx, cricopharyngeus, esophagus). Although there is some variation among reports, in general the bones of herring, salmon, mackerel, trout, blue fish, red fish, and pike are not well seen on plain films. Thus, if one suspects that one of these varieties of bones has perforated, CT may provide greater sensitivity than plain film alone.

The bones of striped bass, sea bass, codfish, flounder, fluke, gray sole, haddock, halibut, porgie, red snapper, smelt, monk fish, plaice, gurnard, and white perch are all usually well seen on plain films and CT. Often on CT, the location of the fish bone is also identified by local enhancement due to an inflammatory reaction and small collections of air from the adjacent pharynx (Fig. 41-16).
FAT-CONTAINING LESIONS

Ordinary Lipoma

Fatty or adipose tissue comprises 15% to 25% of the human body, although in obese individuals fat may represent over 50% of body weight. Ordinary lipomas have been described in virtually every tissue of the body. In general, they are more common in females over the age of 40 years; however, in the head and neck, they may occur more frequently in males. The most common supravacuicular location is the posterior neck, with the anterior or lateral neck and the subclavicular fossa also being frequent sites. Multiple lipomas may be seen in Gardner’s syndrome, multiple endocrine neoplasia, neurofibromatosis, or, rarely, in familial lipomatosis, although lipomas are so prevalent that the vast majority are sporadic.9 Once fat is within a lipoma, it cannot be utilized by the body, even in cases of profound starvation. Thus, when one gains weight a lipoma may enlarge, but when one loses weight the lipoma will not shrink.

Although there are various histologic types of lipoma (myxoid lipoma, angiolipoma, pleomorphic lipoma, spindle cell lipoma, and myelolipoma), on imaging they generally have smooth, noninfiltrative borders and contain almost exclusively fat (Fig. 41-17). Thus, on CT they have a low attenuation, while on MR imaging they have high signal on T1-weighted imaging and intermediate to high signal on fast spin-echo (FSE) T2-weighted imaging. Approximately 8% of ordinary lipomas contain less than 95% fat, in which case the distinction from atypical lipomatous tumors may not be possible.63 Rarely, hemorrhage can occur within an ordinary lipoma, which may be seen in Gardner’s syndrome, multiple endocrine neoplasia, neurofibromatosis, or, rarely, in familial lipomatosis, although lipomas are so prevalent that the vast majority are sporadic.9 Once fat is within a lipoma, it cannot be utilized by the body, even in cases of profound starvation. Thus, when one gains weight a lipoma may enlarge, but when one loses weight the lipoma will not shrink.

Infiltrative (Intramuscular) Lipoma

Intramuscular lipomas are uncommon, benign encapsulated tumors, also referred to as infiltrating lipomas because of their infiltrative growth pattern. Histologically, mononuclear fat tissue is seen between muscle fibers and, in extreme cases, the muscle may be totally replaced by fatty tissue. Careful pathologic examination is necessary to avoid the mistaken diagnosis of a well-differentiated liposarcoma. Complete resection is often difficult, and the postoperative recurrence rate is 3% to 62%. In fact, incomplete resection is favored because development of muscle dysfunction due to fatty infiltration is gradual, and the patient tends to compensate well through recruitment of other muscles. By comparison, the rapid loss of function secondary to the surgical removal of a muscle is, in general, poorly tolerated.

On CT, the fatty mass is typically centered within the normal areas of adipose tissue within the neck. The MR findings of intramuscular lipoma can vary from those of a homogeneous ordinary lipoma to a large, inhomogeneous lesion with an infiltrative margin. The presence of infiltrative margins and intermingled muscle fibers in an intramuscular lipoma indicates a benign lesion rather than a malignancy, and such ingrowth of fatty tissue among the muscle fibers may be seen in up to one third of cases (Fig. 41-18).64 In addition, unilocularity of the mass is helpful in differentiating intramuscular lipomas from the usually multinodular well-differentiated liposarcoma.65–70

Madelung’s Disease

Multiple symmetric lipomatosis, described in Germany by Madelung in 1888 and in France by Launois and Bensaude in 1898, is a rare disease of unknown etiology. It is characterized by the presence of compartmentalized, but unencapsulated, fatty deposits in the neck and upper body. These deposits usually grow slowly, and their initial consequence is purely cosmetic. Rarely, however, they can lead to compression of the larynx, trachea, and cervical esophagus.

This disease usually affects middle-aged males of Mediterranean descent with a history of alcohol abuse. Although most cases have been sporadic, some investigators believe this disorder may be hereditary, and it is thought that this pathology originates from an alteration in lipid metabolism. Surgical removal of the fatty masses is the treatment of choice; however, recurrences are common.71 The fatty deposits can be present virtually anywhere in the neck, but they are predominantly seen in the posterior neck deep to the trapezius and sternocleidomastoid muscles, in the supravacuicular fossa, and between the paraspinal muscles. Less often, the excess fat is seen in the anterior neck, superior mediastinum, pretracheal and prevertebral spaces, and over the cheeks.72 On imaging, the compartmentalized appearance of Madelung’s disease (Fig. 41-19) distinguishes the findings from obesity, in which there is a generalized increase in fat within the subcutaneous tissues (Fig. 41-20). The masses typically show no calcification or ossification, and there is no invasion of adjacent vascular structures.72

Liposarcoma

Liposarcomas represent 15% to 18% of all soft-tissue malignant tumors. They typically develop in the fourth through sixth decades and are more common in males. Liposarcomas are found mainly in the deep soft tissues, unlike lipomas, which usually arise superficially. With few exceptions, liposarcomas are believed to develop de novo and not from ordinary lipomas. About 3% occur in the head and neck, with most occurring in the neck and cheek.63 The treatment of choice is wide surgical resection. Of the 25% to 46% of liposarcomas that recur, most are of the round cell or pleomorphic varieties.

On CT, liposarcomas can appear as ordinary lipomas or they can have variable scattered soft-tissue density (Fig. 41-21). In the more extreme cases, little fat is seen
Well-differentiated liposarcomas can have a variety of MR imaging appearances. Typically, they have features suggestive of a benign lipoma (a well-defined mass with high T1-weighted and low-intermediate T2-weighted spin-echo [SE] signal intensities, with little or no contrast enhancement). In less well differentiated liposarcomas (myxoid, pleomorphic, and round cell), the majority of the tumor typically has a low T1-weighted signal intensity, and only scattered fatty islands and septa may be seen. T2-weighted images usually show most of the mass to be of intermediate to high signal intensity, with fatty islands of relatively low to intermediate signal intensity. Much

**FIGURE 41-17**  A. Axial contrast-enhanced CT scan shows a well-delineated fatty mass in the subcutaneous tissues of the back of the neck. B. Axial contrast-enhanced CT scan shows a well-delineated fatty mass in the subcutaneous tissues of the left neck. Despite the size of the mass, there are smooth, noninfiltrating borders. Axial T1-weighted image (C) shows a well-circumscribed high signal intensity mass situated between the left paraspinal muscles. The lesion is isointense to normal fat. D. Axial T1-weighted, fat-suppressed, contrast-enhanced MR image shows that the mass suppresses like normal fat. All of these patients had ordinary lipomas.
FIGURE 41-18 Axial contrast-enhanced CT scan shows a fat attenuation mass in the right neck. The mass invades the right sternocleidomastoid muscle. This patient had an infiltrating lipoma.

FIGURE 41-19 Axial CT scans (A and B) show multiple discrete fatty masses in the subcutaneous tissues of the back. Axial T1-weighted MR image (C) shows the well-delineated fatty collections in the posterior neck. This patient had Madelung’s disease.
coarser stromal enhancement is seen in the less differentiated tumors.

INTERSTITIAL LESIONS

Fibrosarcoma

Although fibrosarcoma was once described as being among the most common sarcomas, the improved characterization of previously misdesignated fibromatoses has led to a lower reported incidence of fibrosarcoma. As a result, fibrosarcoma now lags well behind malignant fibrous histiocytoma in frequency. Although it can be seen at any age, fibrosarcoma is most common in the fifth through eighth decades; a smaller peak is seen in the neonatal period and in infancy. There is an increased incidence in males and in sites of previous burn or radiation, but other radiation-induced sarcomas, such as malignant fibrous histiocytoma, are more common.

Fibrosarcoma typically presents as a painless, slowly growing mass. It can arise superficially, from deep subcutaneous tissue, or deep within the soft tissues of the neck. Superficial tumors tend to be detected at a smaller size than deeper tumors. The histologic appearance varies, with lower-grade tumors seen as solid and higher-grade lesions demonstrating necrosis and hemorrhage. Distinction of lower-grade lesions from aggressive fibromatoses can be difficult, but only fibrosarcoma will metastasize. The apparently worse prognosis of fibrosarcoma in the head and neck compared with extremity lesions may relate to the inability to obtain adequate tumor margins rather than differing biologic activity.

On imaging, the findings of fibrosarcoma are nonspecific. Low-grade lesions are homogeneous on CT and hypointense on T1-weighted and T2-weighted images. Mild to moderate enhancement is seen on MR imaging but not on CT. Distinction from other aggressive fibromatoses can prove difficult, as they can appear quite similar. However, the presence of necrosis strongly favors the diagnosis of a higher-grade fibrosarcoma. Imaging, particularly MR imaging, has played a major role in defining the extent of these tumors. This is important for proper surgical planning or, if indicated, for planning of proper radiation fields.

FIGURE 41-20 Axial CT scan shows extensive fat in the subcutaneous soft tissues of an obese patient. There are no discrete, well-defined collections of fat, as seen in Madelung’s disease.

FIGURE 41-21 Axial contrast-enhanced CT scan shows a nonhomogeneous but primarily fatty mass in the posterior left neck. Portions of the lesion contour are well defined; others are poorly seen. This patient had a liposarcoma.

FIGURE 41-22 Axial contrast-enhanced CT scan on a patient who had prior surgery on the pharynx and left neck for a liposarcoma. There was a sudden enlargement of the left neck, and this CT scan shows a well-defined, slightly enhancing, nonhomogeneous mass. At surgery, this was found to be a recurrent liposarcoma that had hemorrhaged.
Benign Fibrous Lesions (Fibromatoses)

The fibromatoses are a heterogeneous group of histologically benign fibroproliferative disorders that share characteristics with both sarcomas and fibromatoses. They may be localized or diffuse, symmetric or asymmetric, regressed spontaneously or resist treatment and recur. Fibromatoses are often diagnosed in childhood, but they can occur at any age. Although most follow a benign course, compromise of vital structures may occur. As a group, they do not metastasize.74

The etiology of these fibromatoses is unknown, and the classification of these lesions is mainly based on their clinical findings. Although a number of lesions are classified as fibromatoses, this section will only deal with desmoid fibromatosis, congenital fibromatosis, nodular fasciitis and proliferative fasciitis. Desmoid Tumor

The term fibromatosis without any further qualifiers is generally taken to indicate desmoid fibromatosis, which is an infiltrative process not limited to the fascia. Rather, it arises from musculoskeletal structures and invades the contiguous tissues. Some pathologists consider them well-differentiated fibrosarcomas, particularly when scattered mitotic figures are identified. Unlike abdominal wall desmoids, which are more common in women, there is no clear gender predilection in head and neck desmoids. They are seen in all age groups, although there is a higher incidence in the first few decades of life.74 Patients with Gardner’s syndrome are at increased risk for developing desmoids.

These lesions are typically firm or hard and usually painless, although occasionally they are tender. Most neck desmoids are found in the upper neck; however, those seen more inferiorly may be more difficult to manage, as they can involve the great vessels, trachea, and brachial plexus. They are locally invasive but do not metastasize (Fig. 41-23).74, 78 Surgery is the treatment of choice, and while lesions often extend 2 to 3 cm beyond their apparent boundaries, some cases with positive surgical margins may not recur. Irradiation and chemotherapy are reserved for recalcitrant cases.

Congenital Fibromatosis (Generalized and Localized)

Congenital fibromatosis (infantile myofibromatosis) is a rare disease that starts in utero; however, additional lesions may continue to develop after birth. It presents as multiple superficial tumors of the skin and subcutaneous tissues. However, deep lesions involving the heart, lungs, skeletal muscles, viscera, and/or bones also occur, and many patients succumb to the disease. If the infant survives the first few months of life, the tumors often regress spontaneously over the next 6 to 18 months.68

Somewhat paradoxically, fibrous-rich tissues such as tendons and fascia are rarely affected.

Congenital localized fibromatosis, which may be more common than the generalized form, presents at or just after birth and is localized to just one body area. Typically, the tumors arise in the subcutaneous tissues, skeletal muscle, or bone, and most nonvisceral lesions spontaneously regress. Recurrence following resection of solitary lesions is uncommon.

Histologically, the mesenchymal cells appear more immature than those seen in desmoid tumors, and there is occasional necrosis with calcification that is not seen in other fibromatoses.74 On CT, the fibromatoses usually are infiltrating lesions that have an attenuation equal to or higher than that of muscle and that enhance significantly after contrast administration. On MR images, these lesions usually are heterogeneous and may be either of intermediate or low signal intensity on T2-weighted images. The signal on T1-weighted images is low to intermediate, and there is strong enhancement after contrast administration.77, 78

Nodular Fasciitis (Pseudotumor of the Skin)

Nodular fasciitis is a benign, nonepithelial, self-limited fibroproliferative disorder. Its importance lies in its occasional pathologic confusion with a sarcoma. The head and neck region is the second most common site, lagging behind the upper extremities, where almost half of the lesions are found. Most often, this entity presents in the superficial fascia as a subcutaneous movable nodule that may be tender or painful. However, it also can arise from the deep fascia and may present as an intramuscular mass. Nearly half of the lesions grow rapidly over a few weeks and then slowly decrease in size over the next weeks to months. About 30% of the lesions show no change in size after presentation. Trauma or infection may increase the risk of developing nodular fasciitis, which is believed to represent a reactive or inflammatory process of the myofibroblasts that are normally concerned with skin repair.79 Local excision is the treatment of choice, and a local recurrence (7% of cases) need not be resected if the diagnosis is established.

On CT, subcutaneous lesions are well defined by the adjacent fat, but intramuscular lesions may be poorly defined, usually with an attenuation slightly less than that of skeletal muscle. The lesions are well seen by MR imaging; intramuscular lesions are hypointense to skeletal muscle on T1-weighted and hyperintense to fat on T2-weighted SE images. Subcutaneous lesions may be hypointense to skeletal muscle on all SE pulse sequences or hyperintense on T2-weighted images. Fairly pronounced enhancement occurs after contrast administration (Fig. 41-24). Because there are no unique imaging findings, nodular fasciitis must be included in the preoperative differential diagnosis of small soft-tissue masses.64, 91 Among other lesions to be considered in this differential diagnosis are neurofibroma, schwannoma, fibrous histiocytoma, fibromatosis, fibrosarcoma, myxoid liposarcoma, and myofibrosarcoma.

Proliferative Fasciitis

Though used by many researchers as a synonym for nodular fasciitis, the term proliferative fasciitis should be reserved for a peculiar subcutaneous and facial lesion that may represent the cutaneous counterpart of proliferative myositis. Proliferative fasciitis clinically is similar to nodular fasciitis except that it occurs in older patients and is less nodular and less defined, growing in the superficial fascia. Lesions may be painful, but the clinical course is benign and recurrences are rare.68
FIGURE 41-23  Axial cranial (A) and caudal (B) contrast-enhanced CT scans show a large, homogeneous mass (M) in the left neck filling the posterior triangle of the neck and extending into the supraclavicular fossa. Although the upper boundaries of the mass are fairly sharp, the lower borders merge with the adjacent muscles. Axial T1-weighted MR image (C) on another patient shows an intermediate signal intensity mass in the posterior triangle of the left neck. The lateral boundary is fairly well delineated; however, the medial contour is poorly defined as it projects behind the pharynx and encases the carotid sheath (arrowhead). Coronal T1-weighted, contrast-enhanced MR image (D) on the same patient as in C shows enhancement of the mass. Axial T2-weighted MR image (E) on a different patient shows a high signal intensity mass in the left neck. Although some of the ventral margins are fairly well defined, the posterior boundaries are more infiltrative. All of these patients had fibromatosis. (Figs. 41-23C–E courtesy of Dr. Larissa Bilaniuk.)
Necrotizing Fasciitis

Necrotizing fasciitis is a potentially fatal bacterial infection that spreads within fascial planes. Although it is rare in the neck, possibly due to its relatively rich vascularity, this entity is included because of the potentially devastating sequelae of a delayed diagnosis. Although it was once attributed primarily to extension of dental or pharyngotonsillar infections, numerous case reports have recently implicated sinus infections, epiglottitis, insect bites, radiotherapy, and trauma. Inadequately treated infections can lead to mediastinal extension, considerable necrosis of the surrounding soft tissues and skin, and systemic toxicity.

Relatively constant CT findings in surgically proven necrotizing fasciitis include diffuse thickening and infiltration of the skin and subcutaneous tissue (cellulitis), enhancement and/or thickening of cervical fascia (fasciitis) and dominant muscles (myositis), and compartmental fluid collections. Variable findings include soft-tissue gas, mediastinitis, and effusions. Subsequent CT imaging can demonstrate clinically unsuspected progression of disease, allowing for debridement sooner than would otherwise be considered. MR imaging is sensitive for both cellulitis and fasciitis. In cellulitis without fasciitis, there may be enhancement of subcutaneous tissues or superficial fascia, as well as subcutaneous thickening and fluid collections. When fasciitis is present, however, there is thickening, enhancement, or increased T2-weighted signal intensity within the deep fascia, and deep fluid collections are not uncommonly seen. This fluid represents necrosis or abscess formation, the distinction of which can be difficult, as both are seen as areas lacking enhancement.

MUSCLE-RELATED LESIONS

Levator Claviculae Muscle

The levator claviculae is a normal muscle found in 2% to 3% of the population. The muscle arises from the anterior tubercles of the transverse processes of the upper cervical vertebrae, runs down the neck medial to the sternocleidomastoid muscle, and inserts onto the middle third or lateral half of the clavicle (Fig. 41-25). It may be unilateral or bilateral. The imaging importance of this muscle lies in its recognition as a normal structure rather than as an enlarged lymph node, an unenhanced blood vessel, or some other mass.

Denervation Atrophy

Denervation of a muscle leads to predictable changes that end in a small, atrophic muscle, much of which is replaced by fat. Acute and subacute denervation results in a neurogenic edema that actually causes some muscle enlargement and high T2-weighted signal intensity on MR imaging. Chronic denervation is best seen on T1-weighted images, manifest as a loss of muscle bulk with diffuse areas of increased signal intensity within the muscle corresponding to fatty replacement. On CT, a similar pattern of fatty changes is seen, but it is slightly less well defined than on MR images. The rate of progression varies widely, with some investigators showing acute/subacute edematous findings persisting for up to 48 months after denervation in some patients and chronic fatty changes developing as early as 2 months in others. On both CT and MR imaging,
end-stage fat replacement often results in fatty tissue without any identifiable muscle fibers (Fig. 41-26).

**Muscle Hypertrophy**

Muscle hypertrophy can develop as a result of exercise, in association with myotonic disorders (increased spontaneous activity), or idiopathically (some cases of masticator muscle hypertrophy). In true muscle hypertrophy, the muscle is enlarged but otherwise normal on all imaging. There also can be a pseudohypertrophy of muscle due to infiltration of the muscle by muscular dystrophies, amyloidosis, sarcoidosis, thyroid disease, and parasitic infestations. Lastly, a myositis can enlarge a muscle. On CT, the enlarged hypertrophic muscle may appear normal in density, but abnormal MR signal intensity is seen in most muscles that are enlarged due to pseudohypertrophy or a myositis.

A fairly common example of exercise muscle hypertrophy in the head and neck occurs with masticator muscle hypertrophy and in patients after a radical neck dissection (Fig. 41-27). After surgery, there is shoulder drop following denervation of the trapezius muscle; most patients, therefore, recruit the ipsilateral levator scapulae muscle to elevate the scapula. The resulting hypertrophy of the levator can been seen as a "pseudomass" on imaging, often misinterpreted as a tumor recurrence. Similarly, patients who lift weights often develop hypertrophy of the lower neck, upper back, and shoulder muscles, although these changes tend to be symmetric bilaterally.

**Fibromatosis Colli (Sternomastoid or Sternocleidomastoid Tumor)**

Torticollis may be either congenital or acquired. The cause may be muscular, neurogenic, infectious, neoplastic, posttraumatic, or even psychogenic. When torticollis is caused by a fibrocollagenous infiltration of the sternocleidomastoid muscle with a palpable mass in the newborn, the disease is called fibromatosi colli or sternocleidomastoid tumor. This must be distinguished from muscular torticollis, which is a tightening of the muscle without a palpable mass. However, between 15% and 20% of patients with fibromatosi colli progress to muscular torticollis despite therapy. The right neck is affected in 75% of cases, and rarely, fibromatosi colli may be bilateral. About 70% of the cases present between birth and 2 months of age. Most cases spontaneously regress without resulting deformity, and conservative therapy is the treatment of choice. Although multiple explanations of the exact etiology have been offered, the cause remains unknown.

Sternoclidomastoid tumor presents as a benign, firm, fibrous swelling predominately involving the middle or inferior third of the sternocleidomastoid muscle (Fig. 41-28). This pseudotumor affects 0.4% of infants in their first few weeks of life, with the vast majority showing complete regression over the ensuing few months. On ultrasound, fibromatosi usually appears as a hyperechoic mass or as diffuse enlargement of the sternocleidomastoid muscle of mixed echogenicity; other patterns are identified but are less common. The adjacent soft tissues should remain normal. Although the signal characteristics relative to normal muscle may vary, signal intensity in fibromatosis is slightly increased on T2-weighted images and more significantly increased on gradient-recalled T1-weighted images; the SE T1-weighted signal intensity is essentially normal.

**Muscular Torticollis**

Pathologically, muscular torticollis shows a limited collagenous and/or fibroblastic proliferation that does not cause a mass. It thus might be considered within the spectrum of fibromatosi colli, although 73% of cases of muscular torticollis present after 1 year of age. If it presents prior to 6 months of age, passive stretching may prove beneficial. After that age, a tenotomy may have to be performed.

Congenital muscular torticollis, or idiopathic spasmodic torticollis, may be of unknown etiology, or may be related to
trauma or found in conjunction with a variety of intracranial, atlantoaxial, and spinal pathology. 

Because of the association of congenital muscular torticollis with other intrauterine positioning disorders, it has been postulated that head positioning in utero may selectively injure the sternocleidomastoid muscle, leading to development of a compartment-type syndrome. Singer et al. studied torticollis patients with CT and MR imaging and found signs suggestive of fibrosis within the sternocleidomastoid, which was confirmed at surgery. Although congenital muscular torticollis is usually discovered in infancy or childhood, it may also present in adolescence or young adulthood. It should be considered in the differential diagnosis of nondystonic causes of abnormal head posture.

In a series of pediatric patients who presented with acute torticollis, including some without a history of trauma, almost two thirds (13/21) had atlantoaxial rotatory subluxation (AARS) on CT. It has been suggested that torticollis related to AARS may not adequately resolve until this subluxation is addressed, either with fluoroscopically guided reduction or by fusion. These reports underscore the importance of the cervical spine CT examinations in FIGURE 41-26  Serial axial contrast-enhanced CT scans from cranial (A) to caudal (D) on a patient who has had skull base surgery with damage to his right cranial nerves V, VII, and IX to XII. In A, there is marked atrophy of the right sternocleidomastoid muscle (arrowhead) and fatty replacement of the right-sided tongue muscles. As a result, the right base of the tongue prolapses back farther than the left side, possibly suggesting the presence of a mass on the right. The right internal pterygoid and masseter muscles are also smaller than their left-sided counterparts. In B, there is atrophy of the right sternocleidomastoid (arrowhead) and trapezius muscles. There also is atrophy of the muscles in the right side of the floor of the mouth. In C, the marked atrophy of the right sternocleidomastoid (arrowhead) and trapezius (arrows) muscles is clearly evident. In D, an axial contrast-enhanced CT scan through the lower neck of a different patient who has had a left radical neck dissection shows denervation atrophy of the left trapezius muscle (arrowhead). The right trapezius is normal, but its bulk could be mistaken for a mass (arrow).
evaluating the cause of acute torticollis that does not resolve spontaneously.

In 1969, Snyder described paroxysmal torticollis, which developed in patients between ages 2 and 8 months. The spells of head tilting lasted for a few hours to three days and were occasionally accompanied by pallor, vomiting, and agitation at the beginning of the spells. In most children, the spells stopped spontaneously by age 5 years. This disease may have a familial occurrence, and 12% of patients with benign paroxysmal vertigo of childhood previously had paroxysmal torticollis of infancy. The evaluation of torticollis is often performed by ultrasound, which shows a diffuse enlargement of the sternocleidomastoid muscle. The abnormality may be either isoechoic or hypoechoic, depending on the age of the lesion. Although the enlarged muscle may be mistaken for a mass, it always moves with the muscle on real-time sonography. Because ultrasound is always abnormal in patients with benign paroxysmal vertigo of childhood previously had paroxysmal torticollis of infancy.

The evaluation of torticollis is often performed by ultrasound, which shows a diffuse enlargement of the sternocleidomastoid muscle. The abnormality may be either isoechoic or hypoechoic, depending on the age of the lesion. Although the enlarged muscle may be mistaken for a mass, it always moves with the muscle on real-time sonography. Because ultrasound is always abnormal in patients with benign paroxysmal vertigo of childhood previously had paroxysmal torticollis of infancy.

The evaluation of torticollis is often performed by ultrasound, which shows a diffuse enlargement of the sternocleidomastoid muscle. The abnormality may be either isoechoic or hypoechoic, depending on the age of the lesion. Although the enlarged muscle may be mistaken for a mass, it always moves with the muscle on real-time sonography. Because ultrasound is always abnormal in patients with benign paroxysmal vertigo of childhood previously had paroxysmal torticollis of infancy.
fibromatosis colli, this study should be included in the evaluation of infants with this suspected condition.131

On CT, the enlarged sternocleidomastoid muscle is isodense to normal muscle and either homogeneous or slightly inhomogeneous. On MR images, the muscle can be either isointense or of a lower signal intensity than normal muscle, either homogeneous or slightly nonhomogeneous, and the caudal portion of the muscle is usually more affected than the cranial margin. It is important to exclude other neck masses such as branchial cleft cysts, cystic lymphangiomas, and malignancies such as rhabdomyosarcoma and neuroblastoma.130

Myositis

Skeletal muscle may be inflamed secondary to an adjacent cellulitis and/or abscess. In such instances, technically the term myositis can be applied. The muscle typically is swollen and enhances on both CT and MR images (Figs. 41-29 and 41-30). On MR imaging, the muscle has higher than normal T2-weighted signal intensity, and there is evidence of inflammation in adjacent structures.

The term proliferative myositis describes a rapidly growing pseudosarcomatous lesion of skeletal muscle. In the head and neck, it usually affects the sternocleidomastoid muscle. It tends to occur in older patients, and it is not seen...
Malignancy.

imaging, however, is not typically better demarcated enhancement of the mass. Mature lesions are surrounding edema. Postgadolinium images often show disease. On T2-weighted SE images, early lesions typically chronic phase. Imaging a pseudoin communication to the pathologist if a biopsy is performed.
malignancy. Therefore, the possibility of MOC should be which may hinder histopathologic distinction of MOC from

Myositis Ossificans

Myositis ossificans occurs in two forms. The more common variant is myositis ossificans circumscripta (MOC), which usually is a localized process that occurs outside the head and neck region. The rarer and more diffuse form of the disease is myositis ossificans progressiva. MOC is an uncommon disease that has been reported to occur in patients after trauma, burns, and infections and in patients with no known underlying pathology. Although the etiology remains unknown, most investigators believe that MOC represents a localized nonneoplastic, reactive process that results in the proliferation of undifferentiated mesenchymal tissue that then infiltrates into the surrounding soft tissues. Suggested etiologies include ossification of a hematoma, tearing of peristomial allowing subperistomial cells to invade the muscle, and metaplasia of muscle and connective tissue. Although MOC can involve any skeletal muscle, it is uncommon within the head and neck; it has been reported in the masseter, medial pterygoid, temporalis, buccinator, geniohyoid, genioglossus, sternocleidomastoid, and paraspi

Muscular Dystrophies

The muscular dystrophies are a group of primary muscle disorders that are hereditary in nature. The underlying biochemical defects are not well described. Of the dystrophies, the primary one that affects the neck muscles is fascioscapulohumeral (FSH) dystrophy. Outliers dystrophy, which lies on a spectrum somewhere between Duchenne’s and Becker’s muscular dystrophies, affects the flexor muscles of the neck so that the spine cannot lift the head against gravity. Walking is also affected after the age of 12 years. Other dystrophies, such as Emery-Dreifuss muscular dystrophy and scapuloperoneal dystrophy, affect the shoulder muscles and may uncommonly involve muscle changes seen on neck imaging studies. There also are isolated dystrophies that seem to affect a single group of muscles, such as the extensor back muscles.

FSH dystrophy is inherited as an autosomal dominant trait. Its prevalence is about 1 per 100,000 population. The cause remains unknown. Variable facial weakness is usually first noted in the second decade of life. Shoulder weakness especially affects the scapular fixators. Leg weakness also may occur. A more severe form of the disease occurs in infancy. Treatment is supportive.

On CT, there is almost total fatty replacement of the affected muscles (Figs. 41-33 and 41-34). On MR imaging, the muscle has signal intensities close to those of fat, and the normal low muscle signal intensity is absent.

Myotonic Dystrophy

Myotonic dystrophy is one of the most common dystrophies, with an incidence of 2.5 to 5 per 100,000 population. It is estimated that between 1/20,000 and 1/7500 people carry the gene mutation for the disease. The dystrophy is inherited as an autosomal dominant trait with variable transmission. The abnormality has been mapped as a CTG trinucleotide repeat sequence on the q13.3 band of chromosome 19, and when the disease is inherited from the mother, it tends to be more severe. Paternal transmission is rare.

Typically, the disease presents in the second to fourth decades of life; however, children can also be affected. Commonly, the small muscles of the hands and the extensor muscles of the forearms are the first to atrophy. However, in some patients, ptosis and facial muscle atrophy are the initial findings. Usually affected are the masseter and sternocleido-

inhomogeneous masses with signal intensity close to that of fat on both T1-weighted and T2-weighted images, hypointense rims, and no surrounding edema (Fig. 41-32). If MR imaging of early MOC lesions on both CT and MR imaging. If fine needle aspiration is utilized to arrive at a diagnosis of MOC, a sample of the periphery of the lesion must be obtained.

Surgery is curative.
FIGURE 41-31 Axial contrast-enhanced CT scans (A and B) of the neck obtained 1 week after a 38-year-old male complained of neck pain. In A, there is a vague area of low attenuation and fullness in the left paraspinal muscles (white arrow), and there is a faint curvilinear density (black arrow) that could be interpreted as enhancement within the mass. A more caudal scan (B) shows a vague low attenuation and fullness in the left paraspinal muscles (arrow). Unenhanced CT scans (C and D) obtained 1 month after onset show that in C there is now a well-defined calcified/ossified density (black arrow) within the enlarged, otherwise low-attenuation (white arrow) left paraspinal muscles. This radiodensity corresponds to the area that may have been attributed to enhancement on the prior study (A). In D, there is enlargement and low attenuation in the left paraspinal muscles (arrow).
wrinkled forehead give the patient a distinctive appearance. Virtually all muscles can be affected, and most patients are confined to either a wheelchair or bed by the age of 15 to 20 years. Myotonia may precede muscle weakness (Fig. 41-35). Opacity of the lenses is common.

Also associated is a generalized hyperostosis affecting the skull and skull base. CT findings include thickened bone within the calvarium, mastoid portion of the temporal bone, petrous pyramid, anterior clinoid process, dorum sellae, and clivus. Involvement of the glenoid fossa may lead to dislocation of the temporomandibular joint. Lytic and nonexpansile, sclerotic changes have also been seen in the temporal bone. Patients may also have huge frontal sinuses and a small sella turcica. Less common findings include craniokyphosis, a small nasal angle, narrowing of the internal auditory canals, hypotelorism, and enlargement of the mandible. Changes may be unilateral or bilateral. For the most part, the areas of expanded bone have a grossly normal cortical and trabecular pattern. The cause of these bony findings is still unknown.

Rhabdomyosarcoma

Rhabdomyosarcoma (RMS), the malignant tumor of striated muscle, accounts for 8% to 19% of all soft-tissue sarcomas, and 35% to 45% of such sarcomas occur in the head and neck. Almost all tumors (98% to 99%) containing skeletal muscle are RMS, with the small remainder representing rhabdomyomas. RMS is primarily a tumor of children and young adults, with most cases arising in patients under 12 years and 43% seen in patients less than 5 years of age. It is the most common sarcoma in children and the seventh most common malignancy in children overall after leukemia, central nervous system tumors, lymphoma, neuroblastoma, Wilms' tumor, and bone cancer. Varieties include embryonal, alveolar, pleomorphic, botryoid, and mixed types. Most pathologists consider mixed RMS to be composed of two or more of these histologic types.

More than half of RMS are of the embryonal variety, and of those, 70% to 90% arise in the head and neck or genitourinary tract. Most are seen in patients less than 10 years of age; however, nearly one quarter of cases are seen after the second decade. Regional nodal metastasis occurs in 10% to 38% of cases. RMS is the second most common variety, representing approximately one fifth of all cases of RMS. It occurs mainly in patients 15 to 25 years of age and primarily affects the extremities and trunk. Only 18% of cases occur in the head and neck. Nodal metastases are most common in this variety, with regional lymph node involvement seen in 33% of cases and regional or distant nodal disease in 75% to 85%. Alveolar RMS differs from embryonal RMS only in its gross appearance. About 75% of these tumors arise in the vagina, prostate, or bladder. The remaining tumors arise in the head and neck or bile ducts. Most patients are between 2 and 5 years of age.

FIGURE 41-31 Continued. CT scans (E and F) obtained 4 months after onset show that in E the calcified/ossified density remains on this unenhanced image; however, the low attenuation and swelling of the left paraspinal muscles are no longer seen. Following contrast administration (F), there is now a symmetric and normal appearance of the paraspinal muscles. These findings illustrate the progression of myositis ossificans.
Pleomorphic RMS is seen primarily in patients 40 to 60 years of age, with only 6% discovered in patients less than 15 years of age. Most cases arise in the extremities, and only 7% affect the head and neck. Metastasis is primarily vascular, and only 9% of patients have regional nodal metastasis. Survival is poorest with this variety of RMS.

Clinically, RMS is usually a solitary, rapidly enlarging, firm mass that involves a striated muscle. Since the introduction of radiation and chemotherapy in RMS treatment, there has been significant improvement in long-term survival (now 85% or better). The prognosis correlates more closely with extent of tumor involvement than with tumor type. By location, tumor in the orbit tends to be more localized and has a lower incidence of lymph node metastasis than other supraclavicular tumors; accordingly, orbital RMS has a significantly higher 5-year survival than RMS at other head and neck sites (89% vs. 55%).

On imaging, RMS is seen as a densely cellular infiltrating...
neoplasm (Fig. 41-36). Skeletal muscle is always seen as the site of origin. On both CT and MR imaging, masses are typically homogeneous, with destruction of adjacent bone. Necrosis can be seen, but intratumoral hemorrhage is uncommon and calcification is typically absent. Tumor is isointense to muscle on T1-weighted images and hyperintense on T2-weighted images. Just over half of the cases enhance homogeneously, and the degree of enhancement is similar to that of normal skeletal muscle. In most cases, tumor margins are poorly defined.

Metastasis to Muscle

Hematogenous metastasis to muscle is rare. The relatively low incidence may be related to muscle enzyme inhibitors, the acidic environment of muscle, or the vessel-squeezing effect of muscular contractions. Most frequently, the metastases come from primary tumors in the lung, colon, pancreas, breast, or kidney. Although pain, tenderness, and a mass are usually present, some such metastases may be clinically silent (Fig. 41-37).

THE STYLOHYOID SYNDROMES

Three dominant syndromes are related to the stylohyoid structures: Eagle’s syndrome, styloid carotodynia, and hyoid fasciitis.

Eagle’s Syndrome

In 1937, Eagle described the elongated styloid process syndrome, which consists of pharyngeal pain, referred otalgia, and a foreign body sensation in the throat occurring after tonsillectomy. It is believed that this syndrome develops because of fibrosis between the tonsillar fossa and an elongated styloid process; hence, the symptoms are greatest during deglutition, phonation, and deep inspiration, when maximal pharyngeal movement occurs. Since the time of its discovery, the term Eagle’s syndrome has come to be applied to any patient who has these symptoms and an abnormally elongated styloid process. The normal styloid process may be as long as 2.5 cm. Thus, Eagle’s syndrome may be present whenever a longer styloid process is seen on imaging in a patient, whether or not there has been prior tonsillectomy (Fig. 41-38). Complicating the picture even more is that some patients also have ossified stylohyoid ligament(s), which can themselves fracture and become symptomatic. The treatment, if any, is surgical removal of the elongated styloid process(es). Because there are many asymptomatic patients who have elongated styloid processes and/or ossified stylohyoid ligaments, some clinicians question the validity of Eagle’s syndrome. Nonetheless, in the symptomatic patient, shortening of the styloid process usually relieves the complaint. The presence of an elongated styloid process also makes this structure more prone to injury during flexion-type trauma. The symptoms related to Eagle’s syndrome can also be confused with those

FIGURE 41-33 Axial cranial (A) and caudal (B) contrast-enhanced CT scans show fatty atrophy of virtually all of the muscles of the upper back and the floor of the posterior triangle. This patient had fascioscapulohumeral dystrophy.
attributed to a wide variety of facial neuralgias as well as oral, dental, and temporomandibular diseases.

Styloid Carotodynia

A related syndrome is styloid carotodynia, caused by a normal or elongated styloid process whose tip is deviated so that it causes pressure on either the internal or external carotid arteries. This pressure causes stimulation of the pain-sensitive receptors found in the adventitia of these vessels and results in pain along the vascular distribution of the affected vessel. When the internal carotid artery is affected, pain occurs in the parietal and ophthalmic regions and there is little or no pain below the level of the orbits. When the external carotid artery is involved, the pain is in the ipsilateral face below the level of the orbit. Again, surgery is curative.

Hyoid Fasciitis

The least common of these syndromes is hyoid fasciitis, which is usually found in patients who have not had previous neck surgery. Pain and discomfort in the throat are exacerbated when the patient’s head is turned to the affected side. The head turning stretches the muscles between the hyoid bone and the styloid process. Palpation of the neck elicits tenderness over the region of the hyoid bone. It is believed that this hyoid syndrome may be due to tendinitis/fasciitis of the muscular attachments (and of the attachment of the stylohyoid ligament) to the hyoid bone. Some researchers have proposed that certain patients with similar

FIGURE 41-34 Serial cranial (A) to caudal (C) contrast-enhanced CT scans show extensive fatty degeneration of the muscles of the back, floor of the posterior triangle, and right shoulder. This patient had fascioscapulohumeral dystrophy.
Serial cranial (A) to caudal (C) contrast-enhanced CT scans show fatty degeneration of the sternocleidomastoid and trapezius muscles and, to a lesser degree, the muscles of the floor of the posterior triangle. There is also dilatation of the cervical esophagus, and the patient has a tracheotomy tube. This patient had myotonic dystrophy.

Axial T1-weighted, contrast-enhanced MR image shows an enhancing, poorly defined mass arising in the paraspinal muscles of the left neck. There is invasion of the left side of the vertebral. This patient had a rhabdomyosarcoma. (Courtesy of Dr. Larissa Bilanuk.)
symptoms may instead have a tenosynovitis of the intermediate tendon of the digastric muscle. Treatment of hyoid fasciitis consists of local heat applied to the area and/or injection of an anesthetic combined with corticosteroids along the affected greater horn(s). If these measures fail, relief may be difficult to achieve, as surgery is not considered a good option. 

**BLOOD VESSELS AND VASCULAR VARIATIONS**

**Veins**

There are usually at least three jugular veins on each side of the neck. They are named by their position relative to the sternocleidomastoid muscle. Thus, there are the anterior jugular, external jugular, and internal jugular veins. Of these, the internal jugular veins usually have the greatest venous flow and thus are the largest vessels.

**Asymmetry of the Internal Jugular Veins**

The internal jugular veins are almost always asymmetric, with the right one being larger in nearly 80% of people. In the upper neck, the crowding of structures often prevents passive venous distention, and the asymmetry in the internal jugular veins appears minimal. However, more inferiorly the asymmetry is most notable, as the larger spaces of the neck allow more passive distention of the veins. The asymmetry is usually more evident on CT or MR imaging than it is clinically. The disparity in the size of the veins can be so great as to cause the larger vein to be mistaken for a vascular mass. Tracing the course of the vein clarifies such a case. After a radical neck dissection, the shunting of venous blood to the contralateral internal jugular vein can also cause massive enlargement of the vein (Fig. 41-39); this is a normal postoperative finding.

**Multiple Jugular Veins**

Occasionally, one or both of the internal jugular veins may be multiple. In such cases, the more dorsal of the veins is usually the smaller and may not enhance as well as the larger ipsilateral vein on contrast-enhanced images. In these instances, on axial images the poorly enhanced vein may be mistaken for adenopathy. However, tracing the course of the vein will again clarify the situation.

**Phlebectasia**

Phlebectasia is an uncommon condition of the venous system, possibly of a congenital etiology. Clinically, phlebectasia usually presents as a neck mass that enlarges when the patient performs a Valsalva maneuver, talks, or lies down. This normally asymptomatic mass decreases in size at rest or when the patient sits upright. When the internal jugular vein is affected, it presents as a cervical swelling that can mimic the signs of either a pharyngocele or a laryngocele. Because of its rarity, phlebectasia is frequently misdiagnosed.

In the neck, phlebectasia most often affects the internal jugular vein in both children and adults. However, almost any of the cervicofacial veins, such as the anterior jugular vein or the anterior facial vein, may also be affected. Usually no treatment is necessary for this benign condition, although some authors have recommended surgical excision in selected asymptomatic patients for cosmetic and psychological purposes. Venography, angiography, color Doppler sonography, and CT have previously been used to diagnose this unusual condition.

**Thrombosis**

Thrombosis of the jugular veins can occur secondary to placement of a central line, placement of a portacath, infection, surgery, neoplasm, and intravenous drug abuse. On CT, a thrombosed jugular vein is usually enlarged, and on contrast-enhanced images, an older clot is of lower attenuation than the normal vessel; enhancement of the vasa vasorum causes the vessel wall to be well seen. On dynamic contrast-enhanced CT, a thrombus is usually less dense than opacified blood. An acute clot may appear as dense as contrast-enhanced blood. In such a case, the clot is
FIGURE 41-38 Serial cranial (A) to caudal (C) contrast-enhanced CT scans show elongation of the styloid process bilaterally (arrows). The normal styloid process is less than 2.5 cm. These styloid processes were 3.5 cm. This patient, who complained of pain on swallowing, had Eagle’s syndrome. Coronal CT scan (D) on another patient with Eagle’s syndrome shows bilaterally elongated styloid processes and ossification of the stylohyoid ligaments, virtually extending down to the hyoid bone.

FIGURE 41-39 Axial contrast-enhanced CT scan (A) shows a large but normal right internal jugular vein (arrow). In about 80% of patients, the right internal jugular vein is dominant. Axial contrast-enhanced CT scan (B) of a patient who has had a right radical neck dissection. The right internal jugular vein was resected, and the left internal jugular vein (arrow) has become enlarged.
better seen on either noncontrast images or delayed, contrast-enhanced scans as the vascular density decreases (Fig. 41-40). If inflammation is present, there will be a fasciitis around the vein, with edema of the surrounding fat planes. On MR imaging, jugular venous thrombosis may be more difficult to detect because slow or turbulent flow may mimic a clot.

Lemierre’s syndrome is the association of an acute pharyngotonsillitis (which is an anaerobic oropharyngitis), septic thrombophlebitis of the ipsilateral internal jugular vein, and septicemia with septic emboli, most often to the lungs and large joints. There usually is an associated regional reactive lymphadenitis (see Chapter 38).

Pseudocollateral and Collateral Veins

Due to the current rapid CT scan times and the rapid injection of contrast with power injectors, contrast enhancement of collateral veins in the muscles of the neck and back may become quite conspicuous (Fig. 41-41). Such opacification occurs even when the internal jugular vein is patent and well opacified. In such cases, visualization of these veins does not necessarily imply thrombosis of the great veins in the lower neck or superior mediastinum. However, when asymmetric posterior muscular collaterals are seen, it is usually prudent to check the lower neck and superior mediastinal veins on that side for the possibility of thrombosis.

Condylar Vein

The vein of the condylar canal is a normal emissary vein that exits the skull base through the posterior condylar canal. The condylar vein may be present on one side or both sides, or it may be absent bilaterally. When bilateral, the two veins may be quite asymmetric in size. The importance of familiarity with the condylar vein lies in not mistaking it for lymphadenopathy or a mass (Fig. 41-42).

Arteries

Medial Deviation of the Internal Carotid Artery

The internal carotid arteries are more consistently symmetric than the jugular veins. Thrombosis and dissection of the internal carotid artery are discussed further in Chapter 40 and postoperative thrombosis of the internal carotid artery is shown in Chapter 45. The medial positioning of the internal carotid artery(s) and, less frequently, of the carotid bulb may cause a bulge in the posterior pharyngeal wall; this is shown in Chapter 40 and in Figure 41-43. Recognition of this normal variant, and its inclusion in the written interpretation, will help to prevent potentially catastrophic biopsy of the associated pharyngeal wall fullness.

An aneurysmal dilatation of an artery may also cause an altered course of the vessel that may mimic a mass in the neck. This is especially so in the lower neck (Fig. 41-44).

Aberrant Retroesophageal Right Subclavian Artery

Although an aberrant retroesophageal right subclavian artery may be an incidental observation on CT or MR studies, it occasionally may cause symptoms of dysphagia (dysphagia lusoria). A barium swallow shows the artery’s impression on the right posterolateral wall of the esophagus, and the vessel can be seen on CT and MR studies (Fig. 41-45).

FIGURE 41-40 Axial contrast-enhanced CT scan (A) shows a thrombus in the right internal jugular vein. There is slight enhancement of the venous wall due to enhancement of the vasa vasorum. There is also minimal effacement of the surrounding fat planes secondary to a phlebitis. Axial contrast-enhanced CT scan in another patient (B) shows a thrombus in the right internal jugular vein. The thrombus is lucent, and inflammation due to an associated phlebitis obscures the surrounding fat planes.
aberrant right subclavian artery is associated with nonreurrence of the recurrent laryngeal nerve.

Thrombosis and Dissection

Dissections of the great arteries in the neck can be spontaneous or related to blunt or penetrating trauma, strangulation, manipulation, angioplasty, infection, or intrinsic disorders of the vessels such as collagen-vascular disease. Approximately one fourth of patients with internal carotid artery dissection will develop an associated pseudoaneurysm. In a series of dissections related to manipulation, vertebral artery involvement was four times as frequent as carotid artery involvement; all vertebral lesions were seen around the atlantoaxial region, and 38% were bilateral.

Imaging findings depend on the patient’s age at the time of dissection and degree of resolution. On CT, fusiform narrowing of the arterial contrast column is more reliably demonstrated than actual subintimal hemorrhage. The classic MR appearance is that of a variably sized central flow void with a hyperintense rim or crescent on axial T1-weighted images, although this hyperintensity may not be seen in chronic cases (Fig. 41-46); conspicuity is augmented by fat saturation. MR angiography may falsely represent the degree of vascular compromise due to changes in flow rate through the dissection; the addition of contrast may help to better define the residual lumen.

Aneurysm

Aneurysms of the cervical internal carotid artery are rare lesions that typically present as pulsatile cervical masses. A series of 38 cases demonstrated relatively common associa-
tions with atherosclerosis, fibromuscular disease, dissection, and trauma. These aneurysms tend to arise in the distal third of the cervical internal carotid artery, and pseudoaneurysms are more common than true aneurysms. On imaging, there is intense enhancement. Since there may be significant flow-related signal loss within the aneurysm itself on MR imaging, the lumen may be better appreciated on contrast-enhanced CT (Fig. 41-44).

Hemangioma
Cutaneous hemangiomas are the most common tumors of infancy and childhood; pathologically, they are classified as infantile, capillary, or cellular. These tumors have a characteristic clinical course that consists of rapid postnatal growth (proliferating phase), slow, spontaneous regression (involuting phase), and finally, restoration of either normal or altered skin (involuted phase). Pathologically similar lesions occur in adults, although these lesions do not spontaneously involute. Despite the difference in clinical behavior, most pathologists still tend to refer to all of these lesions as hemangiomas. However, there is an alternative clinical/pathologic classification that restricts the term hemangioma to the typical lesion described above, with benign hemangiopericytoma is an unusual tumor of vascular origin that usually presents as a painless mass. Approximately one in six tumors arise in the head and neck region, less frequently than those seen in the trunk, pelvis/retroperitoneum, and extremities. Males and females are affected equally, and the peak incidence is near the mid-fourth decade, although there is a wide age range at presentation (first through seventh decades). The small percentage of these tumors seen in the neonatal period tend to be more benign, with some maturing to hemangiomas. Benign hemangiopericytomas are characterized histologically by branched vessels lined with normal epithelial cells and surrounded by a connective tissue matrix. Features of malignant transformation include increased mitoses, irregular or unusual vascular spaces, and proliferation of connective tissue; necrosis and hemorrhage do not appear to be common. Up to half of even benign-appearing tumors may recur, and wide local excision is recommended. Patients should be monitored carefully for delayed recurrences, which may be seen a decade or more after initial tumor excision.

The majority of tumors arise in extramucosal sites. The location of the tumor adds prognostic value, since soft-tissue tumors are more likely than mucosal tumors to recur locally and metastasize. The utility of radiation therapy has been questioned, and its use may be limited to tumors with positive margins, high-grade tumors, and recurrences. The tumor may be embolized proactively to minimize blood loss, although many surgeons first use...