Salivary Gland: Oncologic Imaging

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KEYWORDS

• Salivary gland • Neoplasm • Ultrasound • Ultrasound-guided biopsy

KEY POINTS

- Salivary gland neoplasms constitute a wide range of benign and malignant disorders and imaging constitutes an integral part of the initial assessment of a suspected salivary gland lesion.
- Because of their location, the salivary glands are readily accessible with high-resolution ultrasound, which is considered the first-line imaging modality in many centers.
- By providing information regarding the site, nature, and extent of disorder, ultrasound can characterize a lesion with a high degree of sensitivity and specificity.
- Ultrasound can also be used for image-guided interventions with fine-needle aspiration cytology or core biopsy.
- Ultrasound provides a guide if further imaging with computed tomography or magnetic resonance imaging are required.

ANATOMY OF THE PAROTID SPACE

The parotid gland lies in the retromandibular fossa and is bordered posteriorly by the sternocleidomastoid muscle and posteromedially by the mastoid process. The masseter and medial pterygoid muscles are located anteromedial to the gland, along with the mandibular ramus. The gland consists of superficial and deep lobes, which are defined by the path of the facial nerve traveling through the gland. The superficial lobe is readily imaged with high-frequency ultrasound, although the deep lobe cannot be easily visualized in its entirety, because it is partially obscured by the mandible.[1] The facial nerve is also not usually identified on ultrasound; however, its position can be inferred because it passes in a plane just superficial to the adjacent retromandibular vein (RMV). Hence, identification of the RMV allows compartmentalization into superficial and deep lobes. Lying inferior to the retromandibular vein is the external carotid artery, which branches into the maxillary and superficial temporal arteries within the gland (**Figs. 1** and **2**).

The parotid duct, or Stensen duct, exits the gland anteriorly, passes above the masseter muscle, and perforates the buccal fat and buccinator muscle to open into the oral cavity at the level of the second upper molar. Accessory parotid tissue may be found along the course of the parotid duct, arising in approximately 20% of the population.[2] The parotid gland is predominantly a serous gland.

The parotid gland becomes encapsulated later embryologically than the submandibular and sublingual glands, and therefore intraglandular lymph nodes may be found within it. These nodes tend to be located in the preauricular portion of the gland or within the parotid tail. A normal parotid lymph node is oval or kidney shaped with a smooth contour; has a central, echo-bright fatty hilum; and contains a feeding hilar vessel that can be seen on color Doppler ultrasound.

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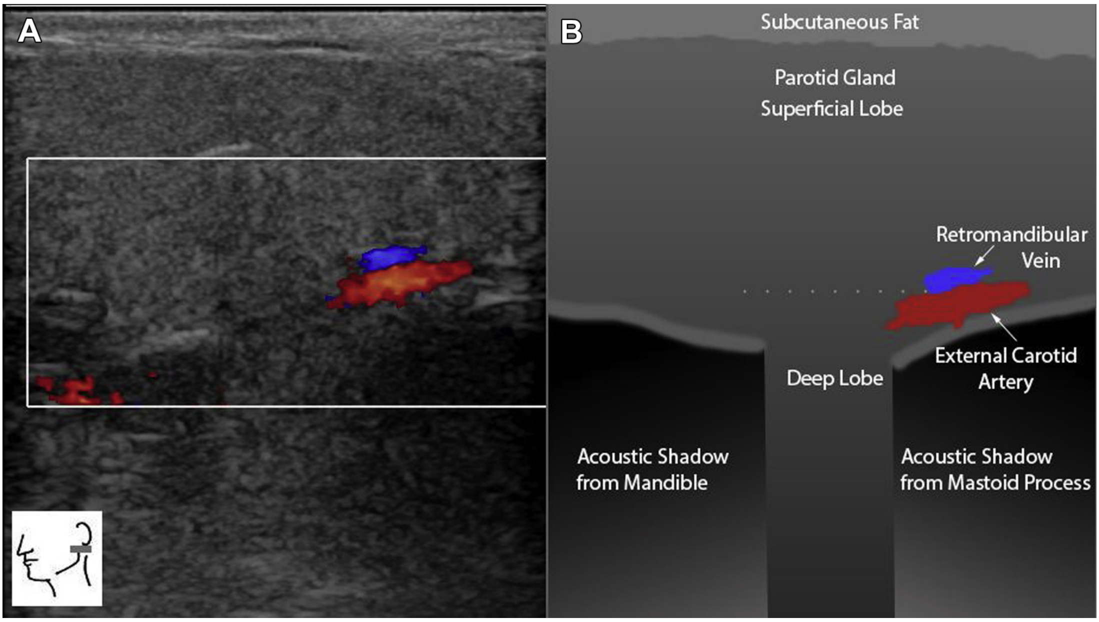

Fig. 1. Transverse sonogram of the left parotid (*A*) with corresponding schematic diagram (*B*), showing the position of the retromandibular vein, allowing compartmentalization into superficial and deep lobes. The probe position is seen in the inset diagram.

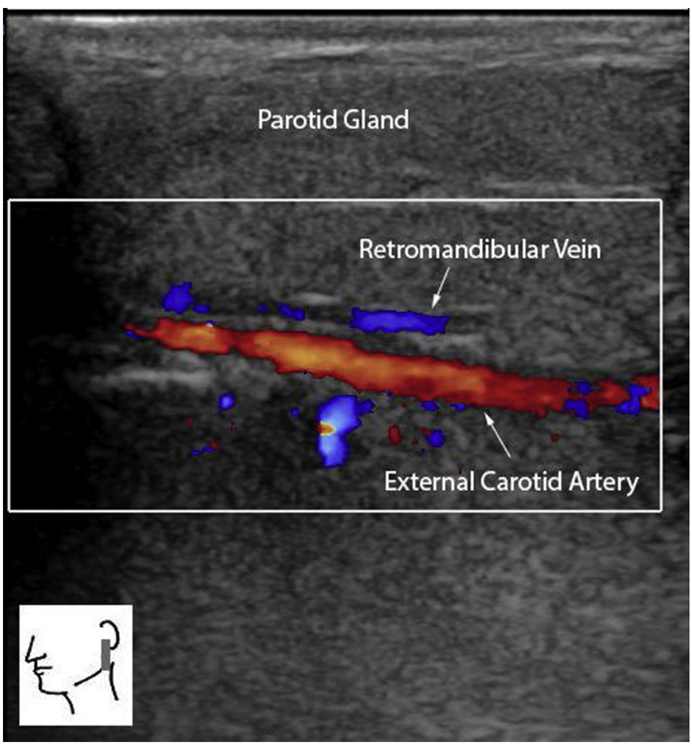

Fig. 2. Longitudinal sonogram of the left parotid showing normal anatomy of the retromandibular vein and external carotid artery.

ANATOMY OF THE SUBMANDIBULAR GLAND

The submandibular gland lies in the space located inferior to the body of the mandible and between the anterior and posterior bellies of the digastric muscle. The gland is roughly triangular in shape and, like the parotid gland, is made up of superficial and deep lobes, although these are of less clinical significance than the parotid gland. The submandibular gland does not contain lymph nodes, although lymph nodes are found within the submandibular space superior and anterior to the gland.[3]

The facial artery arises from the external carotid artery and passes through a groove on the posteroinferior aspect the submandibular gland. The facial artery may pass through the parenchyma of the gland.[3] The facial vein crosses over the superficial aspect of the gland. The marginal mandibular nerve also crosses the gland superficially, within the deep cervical fascia. The submandibular duct (or Wharton duct) originates from multiple ductal branches situated on the deep aspect of the gland, extends anteriorly between the mylohyoid and hypoglossus muscles, crosses the medial aspect of the sublingual gland, and drains into the mouth at the sublingual caruncle, situated on the frenulum lingulae. The submandibular gland is a mixed serous/mucinous gland.

ANATOMY OF THE SUBLINGUAL GLAND

The sublingual gland is the smallest of the 3 major salivary glands. It is situated posterior to the mandible and lies below the mucous membrane of the floor of the mouth. The gland is bordered inferiorly by the mylohyoid muscle and medially by the genioglossus and the submandibular duct. The sublingual gland has a variable number of excretory ducts, many of which drain directly into the floor of the mouth, although some ducts form the sublingual duct of Bartholin, which joins the submandibular duct to drain into the sublingual caruncle. The gland can be visualized on ultrasound when scanning in the submental region and appears as an echogenic oval-shaped structure on transverse imaging.[3] The sublingual gland is a predominantly mucinous gland.

CLINICAL PRESENTATION OF A SALIVARY GLAND TUMOR

Major salivary gland tumors present as painless masses in the region of the affected salivary gland. Benign tumors are usually slow growing, whereas malignant tumors vary in their rate of growth depending on their grade, although a sudden painful increase in size may also be related to infarction (**Fig. 3**). Pain is a poor discriminator between benign and malignant disease because it is experienced in 5.1% of patients with benign tumors and 6.5% of patients with malignant disease.[4,5] However, in patients with proven salivary gland carcinoma, the presence of pain is a poor prognostic indicator, because it signifies perineural spread of disease, which is associated with a 5-year reduction in survival from 68% to 35%. Cranial nerve VII is most commonly involved because of its course through the parotid, thus symptoms include facial pain and facial nerve paralysis. With progressive tumor invasion other cranial nerves may become involved.[6,7]

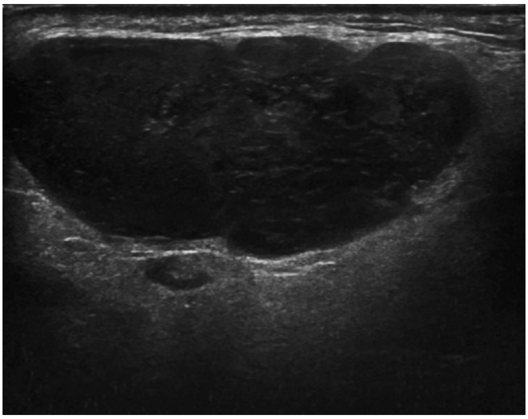

Fig. 3. Sonogram of the right parotid mass in the superficial lobe. This mass is hypoechoic and inhomogeneous. The lesion was painful and had enlarged rapidly, and biopsy confirmed an infarcted Warthin tumor.

Lymph node metastases from a salivary gland tumor may present as a firm enlarging neck lump. The primary drainage for the parotid and submandibular glands is to the deep cervical chain, whereas the sublingual gland drains to submental and submandibular nodes. Nodal metastases are associated with a poorer prognosis, with an associated reduction in 10-year survival from 63% to 33%.[8]

Distant metastasis is also an indicator of poor prognosis and is seen in 20% of the parotid cancers, most commonly from adenoid cystic carcinoma, followed by undifferentiated carcinoma.[6]

THE ROLE OF IMAGING

The diagnosis of a salivary gland tumor ideally is based on the concept of triple assessment:

1. Clinical evaluation
2. Imaging
3. Histologic/cytologic evaluation

Although salivary gland tumors are rare and usually benign, surgical excision represents the treatment of choice in most circumstances. Imaging is needed not only to confirm the presence of a lesion but also to determine its spread, intraglandular/extraglandular extent, identification of clinically occult lesions, as well as unsuspected cervical lymphadenopathy. The imaging characteristics of a lesion can determine whether a tumor is benign or malignant with a high sensitivity and specificity.[9] An accurate preoperative diagnosis of a parotid lesion is critical because many nonneoplastic lesions do not require surgery. The need for surgery may also be avoided in certain benign neoplasms (eg, Warthin tumors) or if the patient is considered too elderly or unfit for surgery. An accurate preoperative diagnosis is an important determinant for operative planning, notably with the increased use of extracapsular, parotid-sparing dissection and to allow appropriate informed patient consent (in particular pertaining to facial nerve integrity and also possible nodal dissection in malignancy).[10,11]

Ultrasound is frequently accepted as the initial imaging modality of choice.[12] It has the advantages of being portable and allowing multiplanar, noninvasive imaging without the need of ionizing radiation. High-frequency linear array probes are capable of producing high-resolution images of the salivary glands with a spatial resolution surpassing computed tomography (CT) and magnetic resonance (MR) imaging. However, compared with these modalities, ultrasound has some disadvantages: it is operator dependent and is limited in visualization of large lesions or those extending into the deep lobe of the parotid because of obscuration by the mandible.[13]

Most lesions lie within the superficial lobe and ultrasound is usually able to compartmentalize a lesion according to its relationship to intraparotid vessels and the inferred position of the facial nerve. For large or suspected malignant lesions and lesions of the deep lobe of the parotid gland, MR imaging or CT are the modalities of choice; however, even in these cases, ultrasound can act as an indicator for additional investigation.[13,14]

Following the initial sonographic diagnosis of a salivary gland tumor, ultrasound-guided biopsy (with fine-needle aspiration cytology [FNAC] or ultrasound-guided core biopsy [USCB]; discussed later) is a safe and reliable method of obtaining the histopathologic confirmation of a lesion necessary to instruct further surgical management.[15–17] The goals of imaging salivary gland tumors can be seen in **Box 1**.

Box 1
The aims of imaging in salivary gland tumors

1. Localization of the lesion
2. Determination of the nature of the lesion
3. Tumor staging for preoperative planning
4. Detection of cervical lymphadenopathy
5. Image-guided biopsy

SONOGRAPHIC TECHNIQUE

A high-frequency linear array transducer, typically 7 to 12 MHz or greater, should be used in the assessment of the salivary glands. A lower frequency transducer (5–10 MHz) can be used to assess large tumors fully and to visualize lesions located in the deeper aspects of the glands.[18–20]

To facilitate visualization, a pillow or towel can placed under the patient's shoulders to extend the patient's neck. The salivary glands and any lesion discovered within them should be interrogated in at least 2 perpendicular planes. An oblique approach may be required to navigate around the mandible. The contralateral salivary gland needs to be examined for comparison and to look for bilateral disease. To complete the study, the entire neck should be imaged for related disorders and lymph node enlargement. Color Doppler assessment provides information regarding the vascular resistance and flow pattern of a lesion, which can improve diagnostic accuracy for malignant tumors.[21]

SALIVARY GLAND NEOPLASTIC DISEASE

When all salivary gland tumors are considered, the global incidence varies from 0.4 to 13.5 cases per 100,000 population.[22] About 80% of all lesions are benign, hence salivary malignancies are rare entities, comprising less than 0.5% of all malignancies and about 5% of cancers of the head and neck.[23] They constitute a wide variety of disorders (**Table 1**). They are divided into benign and malignant neoplasms, which can be epithelial or nonepithelial in origin. The parotid gland contains 70% of all salivary gland tumors, with 8% found in the submandibular glands and 22% in the minor glands.[24]

There are some general rules that apply to salivary gland neoplasms. The smaller the salivary gland, the higher the rate of malignancy. Thus, the rate of malignancy increases from 20% to 25% in the parotid gland to 40% to 50% in the submandibular gland, and to 50% to 81% in the sublingual glands and minor salivary glands.[25–28]

Environmental and genetic factors have been proposed as causes of salivary gland neoplasms. The strongest link seems to be with radiation exposure and smoking, which have been implicated in the development of Warthin tumors.[29]

Table 1
World Health Organization classification of epithelial salivary gland neoplasms

Benign Epithelial Tumors	Malignant Epithelial Tumors
Pleomorphic adenoma	Acinic cell carcinoma
Myoepithelioma	Mucoepidermoid carcinoma
Basal cell adenoma	Adenoid cystic carcinoma
Warthin tumor	Polymorphous low-grade adenocarcinoma
Oncocytoma	Epithelial-myoepithelial carcinoma
Canalicular adenoma	Clear cell carcinoma, not otherwise specified
Sebaceous adenoma	Basal cell adenocarcinoma
Lymphadenoma	Sebaceous carcinoma
Sebaceous nonsebaceous ductal papilloma	Sebaceous lymphadenocarcinoma
Inverted ductal papilloma	Cystadenocarcinoma
Intraductal papilloma	Low-grade cribriform cystadenocarcinoma
Sialadenoma papilliferum	Mucinous adenocarcinoma
Cystadenoma	Oncocytic carcinoma
	Salivary duct carcinoma
	Adenocarcinoma not otherwise specified
	Myoepithelial carcinoma
	Carcinoma ex pleomorphic adenoma
	Carcinosarcoma
	Metastasizing pleomorphic adenoma
	Squamous cell carcinoma
	Small cell carcinoma
	Large cell carcinoma
	Lymphoepithelial carcinoma
	Sialoblastoma
	Soft tissue tumors
	Hemangioma
	Hematolymphoid tumors
	Hodgkin lymphoma
	Diffuse large B-cell lymphoma
	Extranodal marginal zone B-cell lymphoma
	Secondary tumors

Data from Barnes L, Eveson JW, Reichart P, Sidransky D, editors. World Health Organization classification of tumours: pathology and genetics, head and neck tumours. Lyon: IARC Press; 2005. p. 242–3.

BENIGN TUMORS

About 65% of all salivary gland tumors are pleomorphic adenomas, followed by Warthin tumor in 3.5% to 30% depending on geographic location. The remainder are rare benign tumors.[30] On ultrasound these lesions typically appear as smooth, round, hypoechoic masses with distal acoustic enhancement (**Fig. 4**). These tumors may appear lobulated. Large tumors may appear more heterogeneous than small ones and may require further evaluation with MR imaging.

PLEOMORPHIC ADENOMAS

Pleomorphic adenomas represent the most common benign parotid and submandibular tumor. They are of mixed cell origin with considerable variation in the myoepithelial, mesenchymal, and epithelial components. They usually present as slow-growing, asymptomatic masses in middle-aged patients. Pleomorphic adenomas occur most often in people in the fourth and fifth decades of life but may arise at any age. They have a slight female preponderance. About 80% of pleomorphic adenomas arise in the parotid; 10% in the submandibular gland; and 10% in the minor salivary glands of the oral cavity, nasal cavity, and paranasal sinuses and the upper respiratory and alimentary tracts.[24] Of the parotid lesions, 90% occur in the superficial lobe, frequently in the tail. They are usually solitary and unilateral.[22,31]

If left untreated, approximately 5% undergo malignant transformation, usually after a period of decades.[4,22] In view of their malignant potential, surgical resection is the mainstay of treatment. Pleomorphic adenomas treated by surgical enucleation or those that experience intraoperative rupture or transection have a high rate of multifocal local recurrence, and they can rarely behave aggressively, showing metastatic spread.[32]

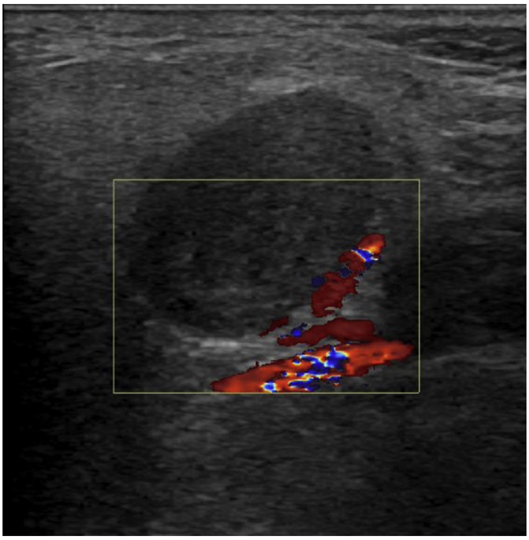

Fig. 4. Sonogram of a parotid pleomorphic adenoma. The lesion is hypoechoic, reasonably homogeneous, and well circumscribed. There is distal acoustic enhancement. Note the relationship to the intraparotid vessels deep to the lesion, locating the lesion to the superficial lobe.

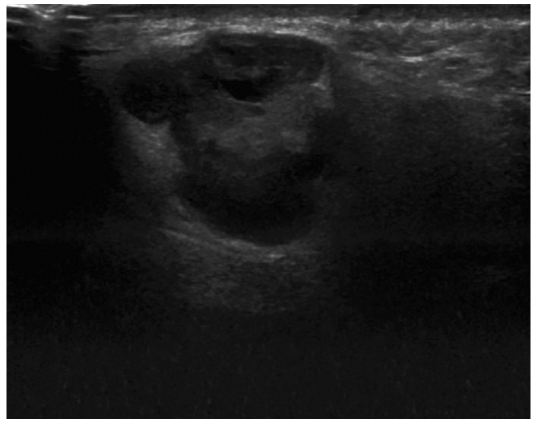

Fig. 5. Sonogram of the right parotid shows a large hypoechoic mass, inhomogeneous and ill defined in parts. This lesion had some sonographically suspicious features, but biopsy confirmed pleomorphic adenoma. As these lesions enlarge they can appear atypical/malignant on ultrasound with ill-defined margins and internal calcification, and cystic change may also be apparent.

On ultrasound, pleomorphic adenomas are characteristically hypoechoic, well-defined, lobulated tumors with posterior acoustic enhancement (see **Fig. 4**). Larger tumors may appear poorly defined with cystic degeneration and internal heterogeneity and can be mistaken for malignancy (**Fig. 5**). Multifocal primary lesions have also been reported.[33] The homogeneity of internal echoes has been regarded as a typical feature of pleomorphic adenoma; however, it is likely to depend on tumor composition.[34–36] Dystrophic calcifications may also form in long-standing lesions and are best visualized with CT.[37–39]

WARTHIN TUMOR (CYSTADENOLYMPHOMA)

Warthin tumor is the second most common benign neoplasm of the salivary gland. It is exclusively found in the parotid and accounts for 20% of all epithelial parotid tumors. It arises from heterotopic parotid tissue within parotid lymph nodes. These tumors present as slow-growing masses within the superficial lobe of the parotid near the angle of the mandible. They are most commonly found in elderly men in the fifth to sixth decade and are associated with smoking and ionizing radiation. Warthin tumors can be bilateral or multiple in 15% of patients. Tumors are metachronous in 75% of multifocal cases.[22,31,40]

On sonography, these tumors are rounded or lobulated hypoechoic masses that may show cystic change with hyperechoic internal septation. They may present as entirely cystic structures, requiring differentiation from other benign and malignant cystic lesions (**Figs. 6–8**).[3,4,41] Biopsy of these tumors can be challenging because of the paucity of solid material; however, core biopsies through the tumor wall may allow histologic diagnosis.

On MR imaging these tumors are homogenous to intermediate signal on T1. On T2-weighted imaging they are intermediate signal with focal hyperintense areas corresponding with cystic components. A characteristic feature of Warthin tumors is their lack of enhancement with gadolinium.[42,43] Warthin tumors show increased tracer uptake on 99mTc scintigraphy.[44]

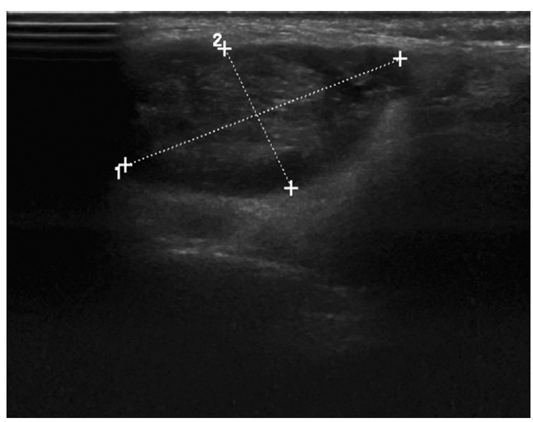

Fig. 6. Warthin tumor (calipers) of the right parotid. Note the inhomogeneous internal architecture and cystic changes.

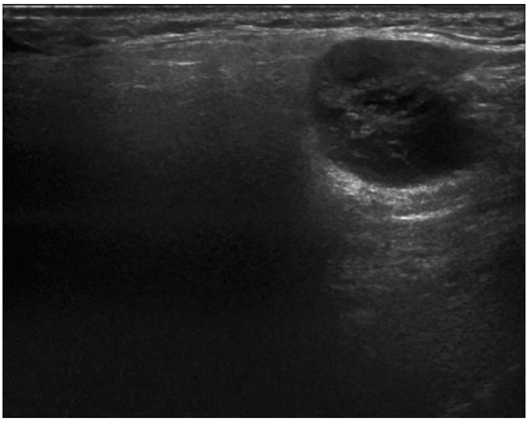

Fig. 7. Sonogram of the left parotid (same patient as in **Fig. 6**) shows a contralateral Warthin tumor.

ONCOCYTOMA

Oncocytoma is an uncommon, benign salivary neoplasm composed of mitochondria-rich epithelial cells called oncocytes. They account for about 1% of all the salivary gland neoplasms.[26] Most (84%) cases occur in the parotid gland,[45] with the remainder occurring in the submandibular and minor glands. They present as slow-growing, painless, mobile masses usually within the superficial lobe of the gland.[41]

Oncocytoma has similar imaging characteristics to pleomorphic adenoma. On ultrasound these lesions appear well circumscribed and lobulated (**Fig. 9**).[4,41]

OTHER BENIGN NONEPITHELIAL TUMORS

Hemangiomas of the salivary glands account for approximately 0.4% of salivary tumors.[46] Lesions

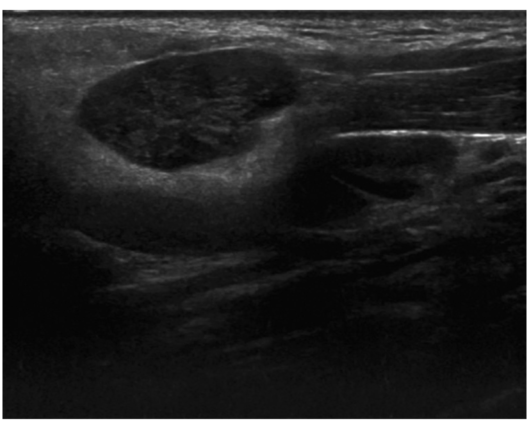

Fig. 8. Longitudinal sonogram of a Warthin tumor in the lower pole of the parotid gland. The lesion is hypoechoic and inhomogeneous but well circumscribed and there is distal acoustic enhancement. The sonographic appearances are similar to those associated with pleomorphic adenoma.

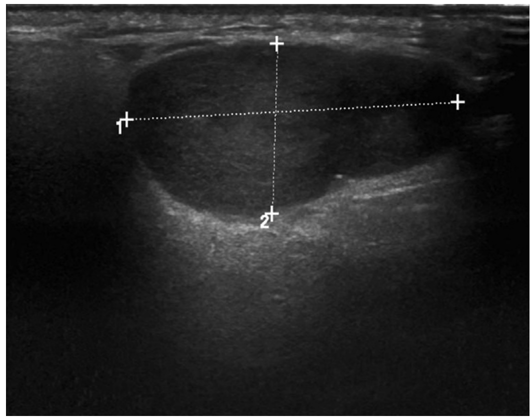

Fig. 9. Sonogram of an oncocytoma; sonographic features are similar to those associated with a pleomorphic adenoma.

may present at any age but two-thirds of cases are diagnosed in the first 2 decades. They are the most common type of pediatric salivary gland tumor arising in infancy and undergo involution usually by the age of 9 years. They are twice as common in female patients as in male patients.[46,47] Hemangiomas of the parotid appear solid and hypoechoic on ultrasound. On color Doppler imaging they show prominent internal vascularity. Calcified phleboliths are commonly seen within these tumors.[21]

Lipomas of the salivary glands are rare; however, they can occur in the parotid and account for approximately 1% to 2% of all parotid neoplasms.[48] On sonography the lesions are usually well defined but can also appear ill defined. They are normally hypoechoic and contain internal echogenic foci or striations.[49]

MALIGNANT LESION

Sonographic features that suggest a malignant lesion are ill-defined borders, hypoechoic and heterogeneous architecture with distal acoustic shadowing, and extraglandular extension (**Figs. 10–12**).

MUCOEPIDERMOID CARCINOMA

Mucoepidermoid carcinoma is the most common primary malignancy of the salivary glands, representing 20% of all salivary gland malignancies. They arise from ductal epithelium.[22,25] Approximately half of tumors (53%) occur in major glands, most frequently in the parotid gland, representing 45%, with 7% in the submandibular glands, and 1% in sublingual glands. The most frequent intraoral sites are the palate and buccal mucosa.[30] Lesions tend to occur in middle-aged adults (35–65 years). Sonographic features depend on the histologic grade of the tumor. Most tumors

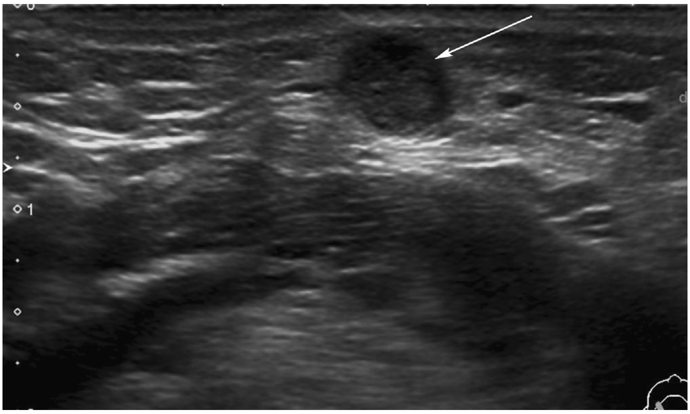

Fig. 10. Sonogram in a patient with a hard nodule in the right submandibular region. The patient had a previous history of a low-grade adenocarcinoma of the right submandibular gland. Ultrasound shows an ill-defined, heterogeneous, hypoechoic solid nodule (*arrow*) that was confirmed as recurrent tumor on biopsy.

are low to intermediate grade, and have a good prognosis with surgery. However, high-grade tumors have a poorer prognosis and increased metastatic potential.[22]

Lower grade lesions appear well defined and may display a lobulated shape with homogenous internal architecture, displaying significant overlap with pleomorphic adenomas both sonographically and clinically (**Fig. 13**). High-grade aggressive lesions are poorly defined, with an irregular shape; blurred margin; and hypoechoic, heterogeneous internal architecture (**Fig. 14**). Tumors may be predominantly cystic or mixed cystic with solid mural components.[9,36,50] Once biopsy has confirmed diagnosis, MR imaging is necessary to complete locoregional staging and a CT of the chest to look for metastatic spread.

ADENOID CYSTIC CARCINOMA

Adenoid cystic carcinoma is the second most common parotid malignancy. It accounts for 2% to 6% of parotid gland tumors and is the most common submandibular and minor salivary gland malignancy.[25]

The tumor presents as a painful slow-growing mass. The tumor is unencapsulated and may appear well circumscribed on ultrasound. These tumors have a tendency for perineural and local invasion, which explains the high incidence of associated facial pain (33%) and facial nerve paralysis. Late recurrence can occur up to 20 years after treatment. Perineural invasion can be accurately assessed with multiplanar MR imaging and abnormal neural enhancement and skull base extension may be seen after contrast.[47,51]

METASTASIS

The parotid gland contains lymphatic tissues and lymph nodes because of its late encapsulation, within which metastatic disease may occur. Metastatic spread is most commonly via the scalp lymphatics with squamous carcinoma (37%) and

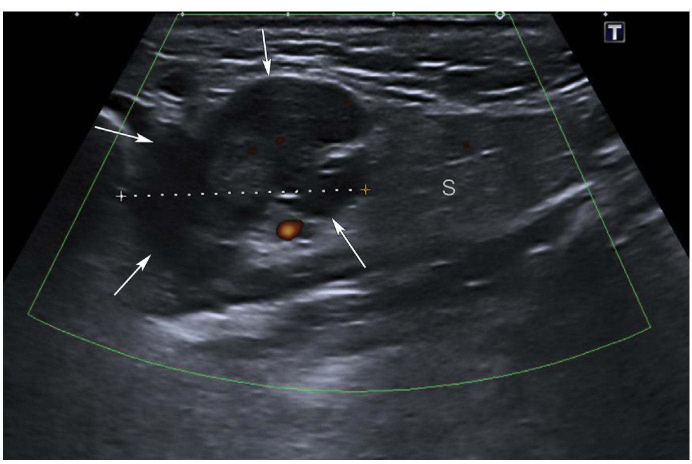

Fig. 11. Sonogram of the right submandibular gland (S) shows an ill-defined mass of mixed echotexture (*arrows*) arising from the lateral aspect of the gland. Biopsy confirmed malignancy.

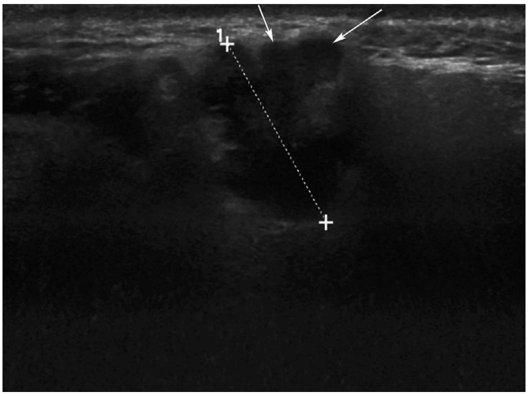

Fig. 12. Sonogram of an acinic cell carcinoma of the right parotid gland (calipers). The lesion is ill defined, heterogeneous, and hypoechoic. Note the extracapsular extension (*arrows*).

melanoma (46%) being the most common primaries.[52] Less commonly lung, renal, or breast carcinoma can spread hematogenously to the parotid gland.[53,54] On ultrasound, metastases vary in appearance: lesions tend to be hypoechoic, with heterogeneous internal architecture and ill-defined margins (**Fig. 15**).[55]

LYMPHOMA

Primary salivary gland lymphoma is rare, accounting for only 5% of all primary extranodal lymphomas and 2% of all salivary gland tumors.[56]

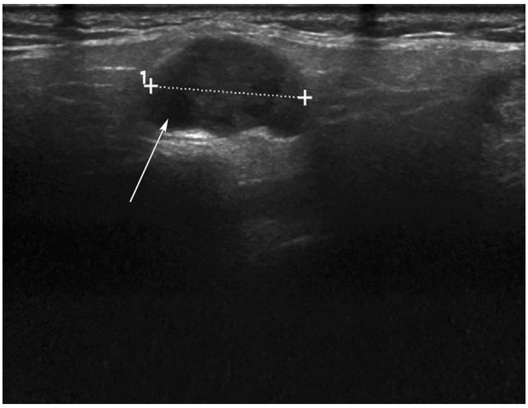

Fig. 13. Sonogram of a right parotid nodule (calipers). The lesion lies in the superficial lobe, it is circumscribed and hypoechoic. There is distal acoustic enhancement and the internal architecture is mildly inhomogeneous, with a poorly hypoechoic focus present (*arrow*). On ultrasound, the lesion appears likely to be benign, with features consistent with a pleomorphic adenoma. However, biopsy confirmed a low-grade mucoepidermoid carcinoma. Small, low-grade malignancies can mimic benign tumors both clinically and sonographically.

The most commonly affected gland is the parotid gland (75%), followed by the submandibular gland (20%). Most lymphomas occurring in salivary glands are mucosa-associated lymphoid tissue (MALT) lymphomas, which are low-grade B-cell non-Hodgkin lymphomas (NHL) that often develop in the setting of chronic lymphoepithelial sialadenitis seen in patients with Sjögren syndrome (**Figs. 16** and **17**).[57,58] Primary and secondary non-MALT lymphomas of the salivary glands may also occur and involvement can be in the form of focal nodal disease or diffuse infiltration of the gland.[39,59]

The imaging features of parotid lymphoma are variable. Focal lymphomatous nodes may have a pseudocystic or micronodular pattern (**Fig. 18**), whereas diffuse involvement may present as generalized enlargement of the gland. There may be associated regional lymphadenopathy and glandular sialectasis. Diffuse disease may manifest with a pattern of multiple hypoechoic lesions with increased vascularity. In these circumstances, differentiation from benign inflammatory conditions is required.[60,61]

CARCINOMA EX PLEOMORPHIC ADENOMAS

There are 3 types of malignancies that occur within preexisting pleomorphic adenomas. The most common is the carcinoma ex pleomorphic adenoma, which originates from epithelial cells; these represent 12% of all malignant salivary gland tumors. The other two forms are true malignant mixed tumor (carcinosarcoma) and metastasizing pleomorphic adenoma.[62,63] Concerning features of malignant degeneration are pain and a sudden increase in size within a long-standing mass. However, this is also seen in tumor infarction (see **Fig. 3**). The rate of occurrence increases with the period the pleomorphic adenoma is left untreated. According to some investigators, the rate of malignant change is 1.5% in the first year in which the adenoma goes untreated, and increases to 9.5% after 15 years.[64,65]

On imaging they look similar to a pleomorphic adenoma, or may show infiltrative margins, necrotic areas, and regional lymph node involvement.

COLOR FLOW ASSESSMENT

Malignant lesions tend to show increased, disordered, and chaotic vascularity compared with benign lesion. Various studies have used different markers of vascularity to differentiate between benign and malignant salivary gland tumors. Some studies have shown that highly vascular lesions and those with a high systolic peak flow velocity (>25 cm/s) are suspicious of malignancy,

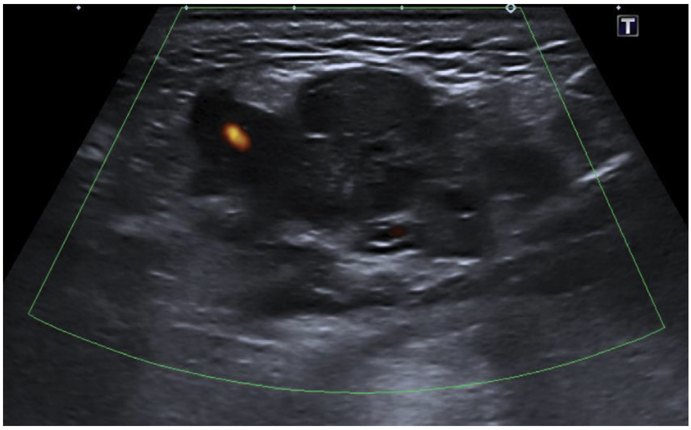

Fig. 14. Mucoepidermoid carcinoma of the left submandibular gland. A large hypoechoic solid mass with ill-defined margins, relatively avascular, replaces normal gland architecture.

regardless of the gray-scale appearance of the tumor. However, measurement of peak systolic velocity in small intratumoral vessels is imprecise, and doubts have been raised regarding the ability to accurately angle correct on small intratumoral vessels.[66,67]

Other studies have measured the vascular resistance of intratumoral vessels, showing that tumors with an increased resistance have an increased risk of malignancy. In those with high pulsatility index (PI) and resistive index (RI), the risk of malignancy increases by a third (PI>1.8 and RI>0.8).[21]

TUMOR MIMICS

Pseudotumors are mimics of salivary gland tumors. Lymphadenopathy in the region of the salivary glands can be misinterpreted as a mass of salivary gland origin. This mass may be secondary to inflammatory conditions such as sarcoid or nodal metastases from head and neck cancers (**Fig. 19**).

Another important example is the Kuttner tumor, a form of chronic sclerosing sialadenitis, presenting as a firm, painful swelling of 1 or both submandibular glands. The disorder is characterized by plasmocytic and lymphocytic periductal infiltrates, which eventually lead to encasement of ducts with fibrotic tissue.[68] On ultrasound, the gland appears diffusely hypoechoic and heterogeneous with multiple small hypoechoic foci with background heterogeneity. Features have been likened to the appearance of a cirrhotic liver. On color Doppler, affected glands showed prominent vascularity.[69] The sonographic appearances are typical and biopsy confirmation is often not required (**Fig. 20**).

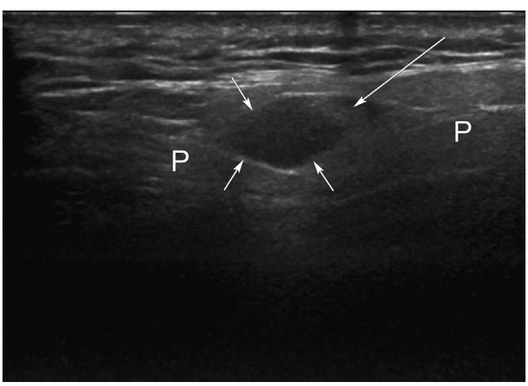

Fig. 15. Sonogram of the right parotid (P) in a patient with a history of previous melanoma excision from the right pinna. Note the intraparotid lymph node (*large arrow*) with a hypoechoic nodule in its upper pole (*small arrows*). Biopsy confirmed metastatic melanoma.

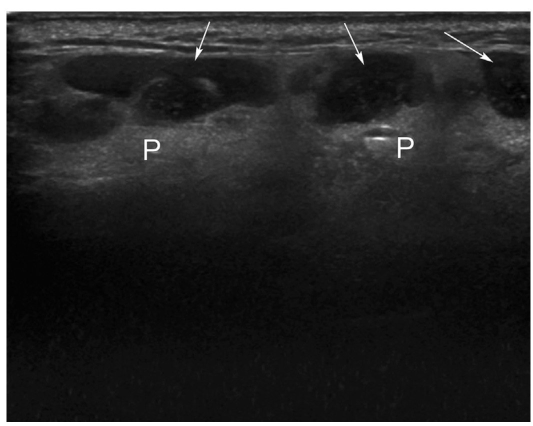

Fig. 16. Sonogram of the right parotid (P) in a patient with known Sjögren syndrome. Ultrasound shows multiple hypoechoic nodules within the superficial lobe (*arrows*). Biopsy confirmed a MALT lymphoma.

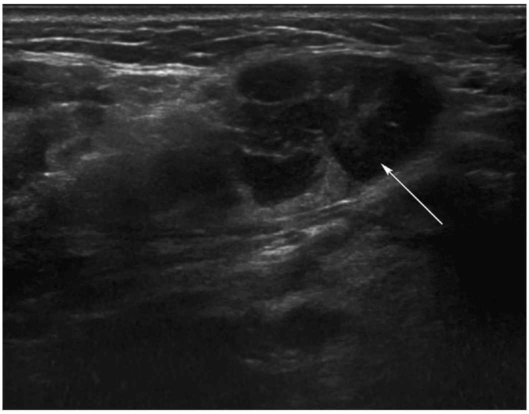

Fig. 17. MALT lymphoma infiltration in the right submandibular gland (*arrow*), in the same patient as in **Fig. 16**.

PITFALLS

Ultrasound is able to determine whether a lesion is malignant with a high sensitivity and specificity of approximately 90%.[9] However, as discussed earlier, there is overlap in characteristics of malignant and benign tumors and distinguishing between the various lesions based on ultrasound criteria alone is not always possible. Therefore, in most patients, ultrasound acts as a guide for further investigation, usually with biopsy in the first instance.

INTERVENTIONAL SALIVARY GLAND ULTRASOUND

Open surgical excision biopsy (SEB), as a method of obtaining a histologic sample, has long fallen out of favor because of the risk of tumor seeding, facial nerve injury, facial scarring, and fistula formation.[70] The accuracy of frozen section diagnoses of the salivary gland is also controversial, with suboptimal accuracy rates for malignancy.[71,72]

Nonsurgical approaches to tissue diagnosis, particularly FNAC, have therefore been widely adopted. FNAC is a rapid and safe sampling technique that can readily be performed in the outpatient setting using ultrasound guidance. With a skilled operator and with on-site histopathologist backup and the latest laboratory techniques, FNAC has a high diagnostic accuracy.[73] However, these services are expensive and not widely available outside large and specialist centers. A recent meta-analysis of FNAC based on 64 studies concluded that FNAC had a sensitivity of 0.79 for a diagnosis of malignancy. In addition to the high false-negative rate for malignancy, the study also highlighted the significant heterogeneity in the performance of FNAC, making it impossible to provide a general guideline for its clinical usefulness.[74]

In general, FNAC is capable of a high specificity, in optimized circumstances, but has a lower sensitivity for the detection of malignancy, thus the false-negative plus high nondiagnostic rates of FNAC are disadvantages.[16,17,75]

USCB has recently been described in the diagnosis of parotid tumors, and is developing into an established technique.[15,76,77] Because USCB provides a larger sample, it potentially has a lower nondiagnostic rate, providing diagnostic biopsies without the need for on-site cytology. The core of tissue provided by USCB can also be used for immunohistochemical analysis, which can help

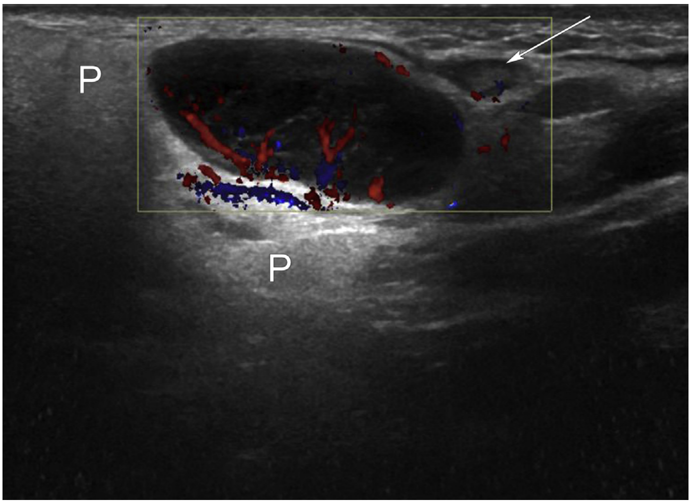

Fig. 18. Sonogram of the left parotid shows a heterogeneous, hypoechoic solid mass with chaotic internal vascularity. Biopsy confirmed infiltration with B-cell lymphoma. Note a small adjacent node (*arrow*) that appears reactive on ultrasound criteria with a large central echogenic hilum and even peripheral hypoechoic cortex.

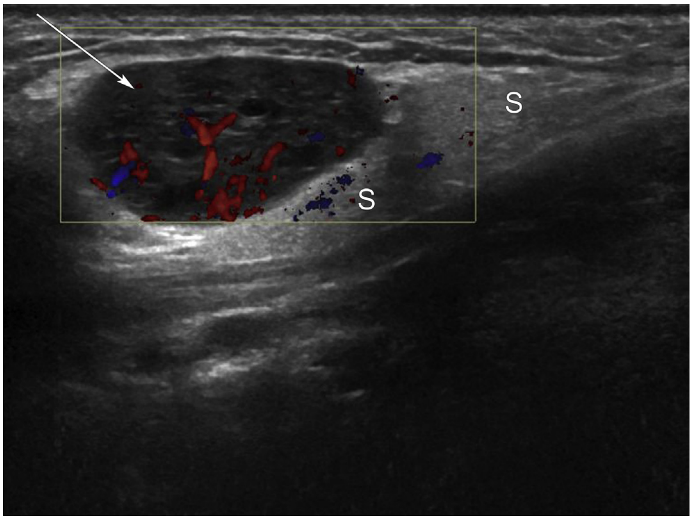

Fig. 19. Sonogram of the right submandibular space in a patient with a palpable mass. There is a mixed-echotexture mass (*arrow*) closely abutting and distorting the submandibular gland (S). Biopsy confirmed a metastasis from a squamous cell carcinoma, the lesion mimicking a submandibular lesion clinically.

with the grading and typing of parotid malignancy that is crucial in diagnosis of lymphomas. Several studies on the performance of USCB have shown the good diagnostic yields from USCB of the salivary glands.[75,78,79] A recent meta-analysis of 6 studies compiled in 2011, evaluating the accuracy of USCB in the diagnosis of salivary gland lesions, concluded that choice of the test (FNAC vs USCB) to use for an individual patient remains undefined; however, the overall accuracy of core needle biopsy is greater than FNAC in some practice settings, with less variability in performance.[80]

NEW DEVELOPMENTS

Sonoelastography is a novel imaging technique that can map the elastic properties of soft tissues.[81] A mechanical force, usually manual compression via the ultrasound probe, is applied to the region of interest. The degree and distribution of tissue deformation is detected and characterized sonographically, and is represented visually as an elastogram of the area of interest. The technique is performed using a 5-MHz to 12-MHz linear array transducer and requires a compatible ultrasound machine. Shear wave elastography (SWE) is a variation of sonoelastography.[82] In SWE, instead of the compressive force of the transducer probe the applied mechanical force consists of focused pulses of ultrasound waves termed push pulses. These induce shear waves that are detected by an ultrafast ultrasound imaging technique. This technique is thought to be more accurate than strain elastography because it produces quantitative estimates of stiffness and is less operator dependent. There have been several studies of the ability of sonoelastography to differentiate parotid neoplasms. These studies have been limited

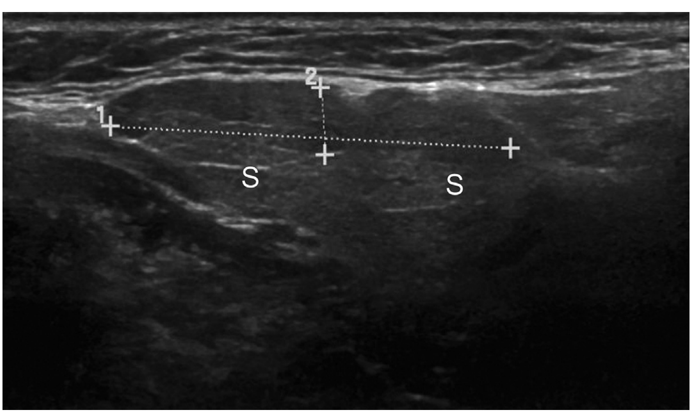

Fig. 20. Sonogram of the left submandibular gland in a patient with a hard left submandibular gland nodule. Note normal gland (S) and a geographic area of reduced echogenicity (calipers). This area is consistent with an area of chronic sialadenitis (Kuttner pseudotumor). Color Doppler assessment can help with the diagnosis, showing vessels passing from the normal to the abnormal gland with no deviation. Biopsy is not normally required to confirm this sonographic diagnosis. A sialogram may be helpful to exclude a duct stone or stricture.

by small patient cohorts and interoperator variability, and the initial results have been disappointing. Recent work focusing on identifying characteristic elastographic patterns within benign and malignant parotid lesions has shown potential in improving preoperative lesion characterization; however, biopsy is likely to remain necessary in the near future.[83,84]

WHAT THE REFERRING CLINICIAN NEEDS TO KNOW

Ultrasound is the initial imaging investigation of choice in virtually all parotid and submandibular gland masses and has a high specificity and sensitivity when differentiating benign from malignant tumors.

Ultrasound-guided biopsy of salivary lesions is a safe, rapid, and accurate method of obtaining tissue samples for analysis. Ultrasound can obviate further imaging if a lesion is sonographically confined to the superficial lobe and confirmed as benign on biopsy.

MR imaging is recommended in the imaging of deep parotid lesions or suspected malignant tumors, for which further assessment of local invasion and perineural spread is required. CT is a useful adjunct for assessing suspected bony involvement and staging lungs in malignancy.

SUMMARY

Salivary gland neoplasms constitute a wide range of benign and malignant disorders and imaging constitutes an integral part of the initial assessment of a suspected salivary gland lesion. Because of their location, the salivary glands are readily accessible with high-resolution ultrasound, which is considered the first-line imaging modality within many centers. By providing information regarding the site, nature, and extent of a disorder, ultrasound can characterize a lesion with a high degree of sensitivity and specificity. Ultrasound can also be used for image-guided intervention with FNAC or core biopsy. It provides a guide if further CT or MR imaging are required.

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