



An insight into ultrasonography of salivary glands: A review

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Abstract

A number of imaging techniques are useful in the assessment of the salivary glands, namely, plain film radiography, sialography, ultrasonography (USG), radionuclide imaging, magnetic resonance imaging, and computed tomography. One of the most common salivary gland imaging modalities is USG, which helps in obtaining information regarding salivary gland pathologies successfully with good accuracy. USG is the best at differentiating between intra- and extra-glandular masses as well as between cystic and solid lesions, local nodal metastases, and local invasion in case of tumors. USG can demonstrate the presence of an abscess in an acutely inflamed gland, as well as sialoliths, which appear as echogenic densities that exhibit acoustic shadowing. In this review, authors have focused on the role of USG in imaging salivary glands in healthy and diseased states and their sonographic features.

Introduction

Major salivary glands in humans are composed of three pairs of macroscopic glandular organs, namely parotid, submandibular, and sublingual. The major salivary glands cooperate functionally to produce saliva in the oral cavity. In addition, there are numerous small minor salivary glands.

Diagnosis of salivary gland disorders is a challenge to any clinician, as they could be involved in a wide array of diseases. The salivary glands are commonly affected by inflammatory, infectious, obstructive, systemic, and neoplastic pathologies. There has been a paradigm shift in salivary gland imaging from utilizing plain films to advanced imaging techniques such as contrast-enhanced radiography, sialography, scintigraphy, ultrasonography (USG), computed tomography, magnetic resonance imaging (non-enhanced and contrast enhanced), and nuclear medicine such as positron-emission tomography (PET).^[1] In addition to localizing the lesion, imaging is essential in determining the extent of disease, involvement of skull base, mandible, and neural spread in case of malignant lesions. Literature evidence states that USG is a superior imaging modality in many aspects as it offers non-invasive, cost-effective, concise, and broad-spectrum imaging of salivary glands.^[2] According to Yousem *et al.*,^[3] ultrasonographic examination by qualified person can supplement both CT and MRI examination in the evaluation of salivary gland lesions. It helps not only

in detection of sialoliths and tumorous lesions but also in describing the structure and vascularity of such lesions. USG also aids in differentiating cystic from solid lesions, in differentiating intraglandular nodes from true salivary gland lesions and detecting ductal calculi and dilatation. Color Doppler ultrasound can be used for identifying vascular supply.

As part of understanding the role of USG in diagnostic imaging of salivary glands, the normal sonographic anatomy of healthy salivary glands is described first in this review followed by a discussion of imaging features of individual disease entities.

Sonographic anatomy of the salivary glands

In an ultrasonograph, all salivary glands appear as homogeneous echogenic organs. Highest frequency linear transducer (5-12 MHz) is commonly used for imaging. For large and deeply seated tumors, 5-10MHZ transducers should be used. For evaluation of the internal structure of salivary gland, probes with median frequency more than 10MHZ should be used.^[4]

Normal parotid anatomy

On an USG, normal parotid gland appears as a homogeneous structure with increased echogenicity relative to adjacent muscle.^[5] The fatty glandular tissue composition of the gland renders the increased echogenicity to the gland in USG. The

parotid gland is divided into superficial and deep lobes by a plane at the level of the facial nerve. The deep lobe is poorly visualized with ultrasound, as it is obscured by the mandible. Normal intraparotid nodes are frequently observed during ultrasound examination. These nodes are generally <5 mm in diameter and appear as well-defined elliptical and hypoechoic with a hyperechoic, fatty, central hilum.^[6] Most commonly, they are seen in a pre-auricular location or in the tail of the gland. The echogenic hilum helps in differentiating intraparotid nodes from other parotid masses. The facial nerve is not routinely visualized with ultrasound although its position can be inferred in relation to main intraparotid vessels which are easily identified.^[7] The retromandibular vein lies deep to the facial nerve along with the external carotid artery. Identification of these vessels are important for compartmentalization of focal lesions.^[2]

The main duct (Stensen's duct) is generally not seen, even with high-frequency transducers, A dilated Stensen's duct may be visualized, running superficially along the masseter muscle through the corpus adiposum buccae and then turning medially through the buccinator muscle.^[5] Normal intraparotid ducts are usually visualized as highly reflective linear structures. In the anterior region, accessory salivary tissue can often be seen.

Normal submandibular gland anatomy

Normally, the submandibular glands have a triangular shape with a posterior base. Normal intraglandular ducts are only rarely visualized. On high-resolution sonography, multiple discrete fine linear streaks represent intraglandular ductules. Anteriorly, the almond-shaped superficial portion runs parallel to the anterior belly of the digastric muscle on an axial plane. The deep portion contains the glandular hilum and lies superomedial to the mylohyoid muscle. The submandibular duct (Wharton's duct) emerges caudally from the hilum near the mylohyoid muscle and lateral to the hyoglossal muscle and is best seen in a slightly oblique plane.^[2] Occasionally, the duct makes a sharp bend as it goes behind the mylohyoid muscle, a common site for a calculus. The length of the duct varies but is approximately 1½ times the axial length of the gland. The duct has a thin echogenic wall, lies medial to the sublingual gland, and terminates distally at the frenulum on the floor of the mouth. The main submandibular duct can be differentiated from the lingual vessels by color Doppler. On a typical oblique section of the submandibular gland, the palatine tonsil can also be visualized as hypoechoic area in a posterior position relative to the submandibular gland.

Normal sublingual gland anatomy

The sublingual glands are localized in the floor of the mouth, cranial to the mylohyoid muscle, medial to the mandible, and lateral to the geniohyoid muscle. In some cases, the salivary tissue can extend posteriorly to the submandibular gland. The sublingual glands have multiple small excretory ducts that are not visible with US.^[1] The glands appear more echogenic than the hypoechoic muscles of the floor of the mouth.

Pathological changes in the salivary glands

Obstructive/inflammatory diseases

In acute inflammation, salivary glands are enlarged and hypoechoic and may have multiple enlarged lymph nodes with increased central blood flow.

Sialolithiasis

Sialolithiasis is defined as the presence of one or more calculi within the salivary glands.^[8] Clinically, sialolithiasis presents with salivary gland swelling and tenderness. Due to obstruction of salivary flow, secondary infection may eventually occur, leading to progressive parenchymal inflammation, atrophy, and fibrosis. Submandibular gland saliva is more viscous, alkaline, and mucous in nature. Hence, more than 80% of sialoliths are associated with submandibular glands.^[5] The calculi are predominantly located in the genu of the Wharton's duct due to its anatomic predisposition for stasis because of its more uphill course and wider lumen. Less commonly, the calculi may form within the intraglandular ductal tributaries or within the gland itself.^[1] Parotid gland calculi are usually detected near the terminal area of the duct or within the gland.^[5]

Compared to other imaging modalities, sonography and MR sialography are the only on-invasive imaging techniques that can be used for detecting a sialolith. Due to its easy availability and lack of invasiveness, sonography is widely used by clinicians to detect sialolithiasis and to monitor patients after treatment. USG can detect 90% of calculi.^[9] The added advantage of USG examination, especially in submandibular gland, is that it can distinguish whether the stone is located within the salivary gland parenchyma or within the duct. However, according to Sylvain Terraz *et al.*,^[8] sonography is not reliable in correctly assessing the precise number of calculi in patients with multiple calculi.

The accepted criteria for sonographic diagnosis of a calculi is, the presence of hyperechoic linear, oval, or round formations with distal acoustic shadowing.^[9,10] The inflamed gland appears hypoechoic.^[9] Stones with smaller dimensions may not show posterior shadowing, or it may be weak. In symptomatic cases with duct occlusion, there is usually an accompanying ductal dilatation which is visible in USG. Hyperechoic bubbles of air mixed with saliva in the duct may mimic stones and cause a diagnostic pitfall.^[11]

Acute inflammation

Acute infections of salivary glands are commonly caused by viruses such as cytomegalovirus or by bacteria such as *Staphylococcus aureus* or oral flora.^[12] Due to the larger orifice of the Stensen's duct, parotid glands are often the primary site for ascending infection from oral cavity. Sialolithiasis is another common cause of acute sialadenitis. If untreated, the infective sialadenitis may progress to abscess formation.^[9] Acute suppurative sialadenitis is commonly seen in debilitated individuals with poor oral hygiene. It causes painful swelling of the salivary gland.^[4] The main indication for ultrasound is to assess whether an abscess formation has developed.^[13]

As discussed above, USG is highly sensitive in the detection of calculus formation and is the initial imaging modality of choice in patients with a history of recurrent salivary gland swelling. In sonography, the salivary gland displays avid enhancement with reduced echogenicity and in homogeneous echostructure with or without multiple hypoechoic areas. Concomitant enlarged cervical lymph nodes with increased central blood flow may be observed.^[10]

In case of abscesses, USG demonstrates ill-defined hypoechoic or anechoic areas with posterior acoustic enhancement. Hyperechoic bubbles of air may be seen within the abscess.^[4,12,14]

Chronic inflammation

Chronic inflammatory disorders of major salivary gland occur due to infectious or non-infectious etiologies. In contrast to obstructive pathologies, chronic non-obstructive pathologies involve parotid gland than the submandibular glands. Non-infectious pathologic conditions include prior irradiation, autoimmune diseases, granulomatous diseases, or idiopathic causes. Patients with chronic bacterial sialadenitis usually presents as a unilateral painful intermittent swelling of the gland, mostly associated with food intake. Strictures or stenosis of the ducts may be precipitating factors.

USG is used mainly to exclude sialolithiasis. The sonographic features include inhomogeneous, hypoechoic areas in a normal sized or smaller sized gland.^[4,12] Intra- or peri-glandular, moderately enlarged lymph nodes with hyperechoic hila may be evident.^[5]

Chronic sclerosing sialadenitis also called as Kuttner tumor is a special form of chronic sialadenitis that may mimic a malignant lesion. At imaging, diffuse involvement of the salivary gland occurs which presents ultrasonographically as multiple small hypoechoic foci scattered on a heterogeneous background of salivary tissue.

Another rare chronic inflammatory disorder of salivary glands is granulomatous sialadenitis. Non-specific USG features such as single or multiple hypoechoic areas in an enlarged or normally sized gland or diffuse low echogenicity may be evident. Blood flow may be increased

In the parenchymal type of tuberculosis, focal, anechoic zones with a cavity within them are seen.^[13,15] The gland is heterogeneous in appearance and less swollen than in acute sialadenitis; duct dilatation may be detected.^[12]

Lymph nodes in sialadenitis

Normal echostructure of the lymph nodes (homogeneous cortex and hyperechoic central hilum) is preserved in acute or chronic inflammation. However, the size will be enlarged. Increased central blood flow in lymph nodes may be observed in acute inflammation.^[12]

Sjögren's syndrome

Sjögren's syndrome (SS) is a chronic systemic autoimmune disorder that principally involves the salivary and lacrimal

glands, resulting in xerostomia (dry mouth) and xerophthalmia (dry eyes). It usually affects the middle-aged women. USG is a promising alternative to other imaging modalities in the diagnosis of SS. On USG, in the early stage, the salivary glands may be normal or show diffuse enlargement with normal echogenicity. The late features include an enlarged gland with heterogeneous echotexture showing well-defined scattered multiple small, oval, hypoechoic, or anechoic areas within the parenchyma which represents destructed salivary parenchyma. Other USG features include dilated duct, enlarged lymph nodes, and associated lymphatic cells infiltration.^[16-18]

There is an increased risk of developing non-Hodgkin's lymphoma in patients with Sjögren's syndrome. Hence, it is recommended that a histological evaluation should be performed in cases which displays signs of Sjögren's disease in USG.^[5]

Chronic sialadenitis and Sjögren's disease share a similar appearance sonographically; however, Sjögren's affect the salivary glands bilaterally in a symmetrical pattern, whereas chronic sialadenitis is usually unilateral.

Sialosis

Sialosis or sialadenosis of salivary gland is a chronic, usually bilateral, diffuse, non-inflammatory, non-neoplastic, recurrent, painless swelling, which most often affects the parotid glands. It is commonly seen in association with various systemic causes. Chronic alcoholism and diabetes are the most common causes. USG depicts enlarged, hyperechoic salivary glands without focal lesions or increased blood flow.^[2,12]

Salivary gland cysts

Cystic lesions of salivary gland may be congenital or acquired (secondary to obstruction, trauma or surgical complication). Ranula is a salivary gland cyst commonly arising from the sublingual gland in the floor of the mouth resulting from ductal obstruction.^[5]

In general, cysts will display well-defined margins, anechoic content with posterior acoustic enhancement in USG. There will be no evidence of internal blood flow at color Doppler imaging.^[2,18] AIDS-related benign lymphoepithelial cysts may manifest as multiple, small hypoechoic areas within the gland; literature evidence states that bilateral presentation is the rule.^[9]

Effects of irradiation on salivary glands

The major salivary glands often affected by head-and-neck radiotherapy due to its anatomic location resulting in post-radiotherapy sialadenitis. In acute stage, glands appear enlarged and diffusely hypoechoic in sonography. In later stages, the glands will be smaller (due to atrophy) and poorly demarcated from the surrounding soft tissues.^[5,19-21]

Neoplasms

Literature evidence states that the probability of a solid lesion being malignant increases with decreasing size of salivary glands, i.e., lowest in parotid and highest risk in minor salivary glands.^[1] In practice, sonographic features are used to evaluate

gland parenchyma and large ducts as well as ductal dilatation in case of neoplastic lesions. Echostructure cannot be used to discriminate among the various histologic varieties of tumor.

The specificity of US in diagnosing tumors can be substantially improved by the use of the color Doppler method, which aids in mapping the blood flow in tumor supplying vessels. US parameters in color Doppler imaging such as intratumor vascularity, pattern of vascular supply, and flow parameters are used to differentiate benign from malignant tumors. Usefulness of color Doppler USG in the pre-histological determination of the biological character of the tumors still remains controversial.

Benign neoplasms

70% of the benign salivary gland tumors are located in the parotid gland. The most common benign neoplasms that affect the major salivary glands are pleomorphic adenomas (mixed tumor) and Warthin tumor (adenolymphoma). Clinically, these tumours present as a slowly growing painless mass.^[22]

Pleomorphic adenoma constitutes 70–80% of all salivary gland tumors, and it commonly arises from superficial lobe of parotid gland. In long-standing tumors, malignant transformation is found in up to 5% of cases.^[9] The histological heterogeneity leads to the varied imaging findings. USG features considered typical for pleomorphic adenomas are well-defined borders, hypoechoic echostructure, and lobulations with posterior acoustic enhancement and may contain calcifications. They have a so-called “pseudo-cystic” appearance.^[5] Homogeneity depends on the composition of the tumor. More and more internal inhomogeneity are being identified when high-resolution transducers are used.^[23] Color Doppler sonography most often demonstrates a moderate vascularization.^[13]

Warthin’s tumor (cystadenolymphoma) is the next most common benign salivary neoplasm arising from parotid intraglandular lymphoid tissue. It is most commonly located in the tail of parotid gland with a propensity for smokers.^[9,24,25] Rarely, it may present in extraparotid locations, most commonly in periparotid lymph nodes. Sonographically, the tumors are oval, hypoechoic, well-defined cystic, or solid mass with heterogeneous enhancement which contains multiple anechoic areas.

Other rare benign tumors salivary gland includes oncocytomas, hemangiomas, lipomas, myoepitheliomas, monomorphic adenomas, and basal cell adenomas. Most of them lack typical imaging features. Hemangiomas in US is visualized as a homogeneous lobular structure with fine echogenic septa. Color Doppler imaging shows extremely high vascularization. Lipomas appear as a well-defined hypoechoic mass with hyperechoic linear echostructures (adipose tissue) regularly distributed within the lesion in a striated or feathered pattern.^[9,12]

Malignant Neoplasms

Mucoepidermoid carcinoma, adenoid cystic carcinoma, undifferentiated carcinoma, and adenocarcinoma constitute the majority of malignant salivary gland neoplasms. Mucoepidermoid

carcinoma is the most common malignant tumor affecting the major and minor salivary glands.^[22] In minor salivary glands, the palate is the most common site for mucoepidermoid carcinoma.

Adenoid cystic carcinomas (ACCs) make up about 6% of all salivary gland tumors, and approximately, 50% of ACC occur in the minor salivary glands. ACC usually presents as a firm unilobular, slow-growing mass in the gland with a high propensity for perineural invasion. The parotid lesions tend to appear as benign, well-delineated tumors, while the minor salivary gland neoplasms usually have malignant infiltrative margins. Retrograde tumor extension to the skull base often occurs through the facial nerve or the mandibular nerve. The clinical presentation and imaging features depend on the grade.

Classic USG features of poorly differentiated malignant neoplasms are a hypoechoic heterogeneous echotexture, irregular shape, ill-defined margins, regional lymph node enlargement, local invasion, and absence of distal acoustic enhancement. However, low-grade tumors may be small (<20 mm in diameter), well-differentiated, homogeneous, and well defined with even margins.^[26] These features create an important hurdle in differentiating them from benign tumors. Hence, in case of focal changes in salivary glands, their verification using an USG-guided fine-needle aspiration biopsy is recommended.

Schick *et al.*^[27] reported that high vascularity and high systolic peak flow velocity are suggestive of malignancy, whereas Bradley^[28] has stated that tumors demonstrating an increased intratumoral vascular resistance index have an increased risk of malignancy.^[12]

Metastases

Metastatic lesions in salivary glands are very rare.^[9] Metastases to salivary glands most frequently arise from primary tumors located in head-and-neck region, as well as other parts of the body. Sonographically, metastatic tumors are well defined, and at times, it may be difficult to distinguish multiple metastatic lesions from some patterns of inflammation, Sjogren’s syndrome, and granulomatous disease at US.^[12]

Table 1 demonstrates the USG features of major salivary gland disorders.

Common errors in USG imaging of salivary glands are

1. Lack of knowledge of normal anatomy and sonographic features of healthy salivary glands.
2. Similarity of USG images in different salivary gland diseases.
3. Technical difficulties (patient related): Short neck, limited neck mobility, poor tissue transparency (obesity), post-operative scars/fibrosis, subcutaneous emphysema, and non-cooperative patient.

Conclusion

USG is a powerful tool to diagnose sialadenitis, sialoliths, inflammatory conditions, differentiation of salivary gland enlargement, and lymph node enlargement and for

Table 1: Ultrasonographic features of major salivary gland disorders

Salivary gland disorders	Borders	Size of gland	Echogenicity	Internal echoes	Distal Acoustic enhancement
Acute sialadenitis	Ill-defined	Enlarged	Hypoechoic	-	-
Abscess	Ill-defined	Enlarged	Hypoechoic or anechoic	Hyperechoic foci	+
Sialolith	Clear (Linear/oval/round)	Normal/enlarged	Hyperechoic	-	+
Chronic inflammations	Ill-defined	Normal/smaller	Hypoechoic (single/multiple)	-	-
Sialosis	Ill-defined	Enlarged	Hyperechoic	-	-
Sjogren's syndrome	Well-defined	Normal	Multiple hypoechoic/anechoic spots	-	-
Cysts	Well-defined	Normal/enlarged	anechoic	-	+
Pleomorphic adenoma	Clear (Lobulated)	Enlarged	Hypoechoic	Hyperechoic foci (in case of calcifications)	++
Warthin's tumor	Clear	Enlarged	Hypoechoic	Anechoic foci	Weak enhancement
Malignant tumor	Ill-defined	Enlarged	Hypoechoic	± (Non-homogeneous)	-

-: Absent, +: Present, ±: May be present/absent

characterizing salivary gland tumors. Clinicians should be familiar with the normal sonographic anatomy and imaging features of various disease processes of salivary glands for thorough evaluation and treatment planning. Ultrasound can be used as the first-line modality to differentiate intraglandular lesions from periglandular pathologies. Although it gives good results to confirm malignancy, it should be kept in mind that US examinations should be handled by well-experienced radiologists. Small, well-differentiated primary parotid gland malignancies may appear benign on ultrasound. In case of abnormal focal changes, an ultrasound-guided fine-needle aspiration biopsy should be considered.

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