Salivary gland imaging

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by Stefanie C Thust
Neuroradiology fellow
Richard J P Smith
SpR Radiology
Polly S Richards
Consultant radiologist
Barts Health NHS Trust, London

The salivary glands are exocrine glands with two main functions: Firstly, saliva production aids the passage of food via the oesophagus into the stomach; secondly, salivary enzymes initiate the breakdown of nutrients, thus forming the first step of digestion. Salivary glands can be divided into major and minor glands. There are three paired major glands, namely the parotid, submandibular and sublingual glands, and numerous minor salivary glands scattered throughout the upper aerodigestive tract including the nasal and oral cavity, paranasal sinuses, soft palate, larynx and pharynx. Various diseases may affect the salivary glands, either in isolation or as part of an underlying systemic condition. Broadly, these can be grouped into benign non-neoplastic conditions, benign neoplasms and malignant neoplasms. As an approximate rule, the risk of malignancy in a lesion increases with decreasing gland size, being highest in the minor glands.

Salivary gland imaging

Different imaging modalities can be valuable in assessing salivary gland disease, whereby the choice of modality will depend on local protocol, clinical features and, importantly, the site of suspected pathology. Owing to technical advances, in many centres ultrasound is nowadays the investigation of choice for major salivary gland disease. It allows a quick, cheap and thorough assessment without the use of ionising radiation and can additionally be employed as imaging guidance for fine-needle aspiration (FNA) and core biopsy.

Ultrasound is able to simultaneously evaluate gland parenchyma and large ducts as well as demonstrate duct dilatation. Stimulation of saliva with a sialogogue often reveals the cause of sialectasis. Digital subtraction sialography (DSS) remains useful in the detection of calculus disease, particularly where ultrasound is inconclusive or negative despite a convincing history. DSS can also be used to guide endoluminal procedures such as basket extraction of small mobile stones and balloon dilatation of salivary duct strictures.

Magnetic resonance sialography (MRS) may be used to assess sialectasis when DSS is contraindicated, with the additional advantage of allowing simultaneous parenchymal assessment. MRS employs a T2-weighted non-contrast sequence and the use of a sialogogue can improve duct visualisation. Due to its excellent soft tissue contrast and ability to assess deep structures, MRI is the modality of choice to evaluate minor salivary gland disease, perineural spread or skull base involvement of malignant tumour of any salivary gland, and deep lobe of parotid lesions for surgical assessment. CT imaging is highly sensitive in detecting radiodense salivary calculi and is particularly useful in assessing multiple clustered calculi, which may be difficult to distinguish on ultrasound. Although the soft tissue contrast of CT is usually inferior compared to MRI, contrast-enhanced CT plays a role in the imaging of acute inflammatory pathology, facilitating quick assessment of sick patients requiring urgent intervention, for example in a suspected abscess or where there is concern regarding airway compromise.

Benign non-neoplastic disease

Salivary calculus disease (sialolithiasis) is a common disease affecting the major glands, particularly the submandibular gland due to its relatively increased mucus content and narrow duct orifice. Approximately 80% of stones develop in the submandibular gland compared to 19% in the parotid. Calculi are multiple in 25% of cases and can reach several centimetres in size. On ultrasound calculi are seen as hyperechoic foci with post-acoustic shadowing. The sensitivity of ultrasound for the detection of calculi has been reported around 90% and depends on calculus size and location, whereby small calculi near duct orifices tend to be most difficult to identify. The use of palpation and a sialogogue as part of an ultrasound examination may help localise stones. Sialolithiasis typically presents with ‘meal-time syndrome,’ ie gland swelling induced by eating. It is the commonest cause of duct enlargement (sialectasis) and may be a source of (recurrent) infection.

Inflammatory parenchymal diseases can be divided into unil glandular and diffuse multiglandular pathology. Bacterial sialadenitis tends to be unil glandular as sequelae of sialectasis but often occurs on a background of a severe underlying critical illness, for example severe dehydration, immunocompromise or in the neonatal period. Ultrasound demonstrates an enlarged hypoechoic gland with hypervascularity and associated reactive lymphadenopathy near the gland. Of note, the parotid gland is the only salivary gland which may also contain intraglandular lymph nodes. Imaging features of benign reactive lymphadenopathy are regular enlargement with a preserved nodal shape, echogenic hilum and vascular architecture. Complications such as abscess formation or airway compromise may ensue from bacterial sialadenitis. In severe cases cross-sectional CT or MR imaging may be needed to assess for deep spread. Chronic sclerosing sialadenitis is a rare benign inflammatory condition of the submandibular gland of uncertain aetiology, possibly related to underlying occult duct strictures and/or calculus disease. It eventually results in gland atrophy, fatty parenchymal replacement and fibrosis that can present as a hard mass and mimic a malignant neoplasm. An uncommon juvenile form, ‘recurrent parotitis of childhood,’ is recognised in which recurring episodes clinically resembling mumps begin in early childhood with resolution of symptoms by the mid teens.

In contrast to bacterial sialadenitis, viral sialadenitis typically affects the parotid glands in a symmetrical fashion, and can be caused by a variety of agents such as mumps, coxsackie A virus, Ebstein-Barr virus (EBV) and cytomegalovirus (CMV). Ultrasound demonstrates diffusely enlarged, hypoechoic and hypervascular glands, an appearance, that on imaging grounds alone, may be difficult to distinguish from other diffuse inflammatory diseases.
Sjogren’s syndrome is an autoimmune inflammatory condition that results in diffuse multiglandular parenchymal abnormality. Clinically it causes dry eyes (keratoconjunctivitis sicca) and a dry mouth (xerostomia) and can occur either in isolation as ‘Sicca syndrome’ or in combination with an underlying collagen vascular disorder such as rheumatoid arthritis or systemic lupus. The disease process involves lymphocytic infiltration of salivary glands with destruction of the normal gland architecture, resulting in formation of pseudocystic acini initially and larger cysts in advanced disease. These can be seen as hypoechoic foci on ultrasound or as multiple T2 hyperintense foci within the glands on MRI. In advanced disease, lymphocyte aggregates can also lead to formation of mass-like components, which may be confused with a neoplasm. Bacterial superinfection in diffuse glandular disease may also complicate imaging findings with a mixed picture.

Sarcoidosis is another autoimmune condition to affect multiple salivary glands. Its glandular appearances may be indistinguishable on imaging from Sjogren’s as a result of non-caseating granulomatous infiltration, although it is more typically accompanied by systemic lymphadenopathy. Sialadenosis is characterised by diffuse enlargement fatty infiltration of the major salivary glands, which can be seen as generalised hyperechogenicity on ultrasound. It is a reversible non-inflammatory condition seen in diabetes mellitus, alcoholism and hypothyroidism.

There are a number of causes of cystic lesions of the salivary glands. Sialoceles are cystic dilatations of salivary ducts and occur secondary to obstruction. Cyst formation in the salivary glands presents as anechoic areas on ultrasound and fluid signal on MR/CT respectively. Retention cysts containing salivary content are called ranulas and most often occur in the sublingual gland. If a ranula ruptures or extends into the submental or submandibular triangle due to dehiscence of the mylohyoid muscle, it is called ‘plunging’ or ‘diving’. First branchial cleft cysts are congenital abnormalities and present as a pretragal intraparotid swelling, which can be simple cystic on ultrasound, but frequently contains echogenic debris. Benign cysts may also occur as part of HIV sialopathy affecting up to 5% of patients prior to the onset of AIDS. Lymphovascular malformations are slow-growing multicystic lesions, which may intermittently enlarge as the patient ages. They often contain blood flow, but this may be too slow to detect on Doppler ultrasound. MRI may reveal blood product in the form of T1 hyperintensity, blood-fluid levels or haemosiderin staining. The presence of phleboliths (characteristic rounded calcific deposits, which occur in veins) is pathognomonic.

**Benign neoplasms**

Pleomorphic adenoma is the most common benign salivary gland tumour, usually arising in the parotid. On ultrasound, these typically appear as solitary homogenous lobulated lesions with only mild vascularity and acoustic enhancement. On MRI, their T2 signal is similar to water, but they usually demonstrate homogenous contrast enhancement. Larger lesions can demonstrate calcification and necrosis, which may lead to misdiagnosis as malignancy. Importantly, approximately 10% of pleomorphic adenomas show malignant transformation over time, therefore excision should be performed. Lesions contain a pseudocapsule and care should be employed during surgery not to rupture this, as seeding may lead to diffuse recurrence. Warthin’s tumour is the second common salivary neoplasm, typically occurring in older male patients, with a propensity for smokers. It arises from parotid intraglandular lymphoid tissue, typically in the tail, and is multiple or bilateral in approximately 15% cases. Ultrasound shows an ovoid hypoechoic mass with a vascular echotexture and this may produce blood-stained mucous-like material on FNA. Of note, while imaging features may be suggestive of a particular (benign) lesion, these are by no means specific, and it is mandatory to perform cytological evaluation of any solitary or dominant salivary gland mass.

**Malignant neoplasms**

US with FNA is the first line investigation for all major salivary gland masses, with MRI reserved for surgical planning and staging of proven malignancies. It allows high resolution assessment for local spread, especially to deeper structures. The most common salivary gland malignancy is mucoepidermoid carcinoma, a tumour that typically occurs in the parotid gland and can resemble pleomorphic adenoma on imaging. Adenoid cystic carcinoma is the most common malignancy of the minor salivary glands, submandibular and sublingual glands and has a poor prognosis, with frequent incidence of nodal and pulmonary metastases. Primary squamous cell carcinoma of the salivary glands is extremely rare, as there is no squamous epithelium within normal salivary glands. However, squamous cell metastases from a non-salivary head and neck cancer may commonly metastasise to intra or periglandular lymph nodes and can therefore be confused with a primary salivary malignancy. Secondary lymphomatous involvement of the salivary glands is relatively common, particularly in high grade lymphomas, and can produce diffuse and multifocal abnormalities on imaging. It is paramount that any imaging assessment of the salivary glands includes evaluation of the cervical lymph nodes, as these may be involved in benign and malignant conditions. Imaging features of malignant lymph node involvement include abnormal shape, loss of the normal hilar architecture and deranged or peripheral vascularity.

**Summary**

A variety of modalities may be employed in salivary gland imaging depending on clinical features, the site of suspected pathology and local protocol. Ultrasound has emerged as the technique of choice for major salivary gland disease and forms a useful aid for FNA biopsy. Any solitary or dominant salivary gland mass should undergo cytological evaluation. MRI is of particular value in delineating and staging salivary gland malignancy.

**References**

FIGURE 1
US image of sjogren’s syndrome of a salivary gland demonstrating multiple scattered cysts and hypoechoic solid masses.

FIGURE 2
Digitally subtracted sialograph (left) and screening radiograph (right) demonstrating a stricture which is then balloon dilated.

FIGURE 3
An axial T1 weighted image through the parotid glands demonstrating a carcinoma in the left parotid gland that arose from a preceding pleomorphic adenoma.

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TABLE 1
Uniglandular vs multiglandular and systemic disease.