IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 21, Issue 4 Ser.10 (April. 2022), PP 01-06
www.iosrjournals.org

Current Concepts and Interpretation of Salivary Gland Imaging – A Review

Dr Rucha Pandharipande
Assistant Professor
Department of Oral Medicine and Radiology
VSPM'S Dental College and Research Center, Nagpur

Dr. Mukta Motwani
Professor & HOD
Department of Oral Medicine and Radiology
VSPM'S Dental College and Research Center, Nagpur

Abstract
Salivary glands are affected by variety of pathologies. Salivary gland imaging plays an important role in diagnosis and management of salivary gland diseases. Selection of appropriate imaging method and accurate interpretation is of paramount importance. Ultrasonography is the first line imaging modality for salivary gland diseases followed by sialography. CT and MRI are helpful in determining the extent and nature of pathology particularly in salivary gland tumors. CT and MRI can be combined with sialography whenever and wherever necessary. Proper interpretation of the radiographs is necessary to make definite diagnosis and successful treatment plan. This review article briefly describes various methods of salivary gland imaging and current concepts of interpretation of these imaging techniques.

Keywords: *salivary glands, imaging, ultrasonography, radiography, interpretation.*

Date of Submission: 06-04-2022 Date of Acceptance: 21-04-2022

I. Introduction

Saliva is the mixed glandular secretion which helps to maintain lubrication, cleanses food debris and aids in swallowing. There are three major salivary glands the parotid, submandibular, and sublingual glands as well as minor salivary glands. The salivary glands produce 1.5 liters of saliva every day, out of which 70-75% is contributed by submandibular gland, 20-25% is contributed by parotid gland, and 5% by sublingual gland.(1)

Salivary gland is affected by number of diseases such as bacterial, viral and rarely fungal infections. Sometimes the gland is affected by ductal obstruction which may cause painful swelling thus affecting their functions. The salivary gland may also be affected by a various benign and malignant tumor. (2)

Salivary gland imaging aid in better diagnosis of salivary gland pathology and is useful adjunct to clinical examination. The main indication of salivary gland imaging is pain and swelling. It is useful in identifying masses of salivary glands and also differentiating them from the masses /pathologies of adjacent cervical spaces, especially parapharyngeal, masticator, and submental spaces and mandibular lesions. Salivary gland imaging helps to delineate the extent of the lesion and invasion of adjacent cervical spaces, skull base, mandible. Depending on pathology and patient factors selection of imaging modality should be done. The following Imaging techniques of salivary gland are used. (3)(4)(5)(6)

1. Conventional Radiography
2. Sialography
3. Ultrasonography
4. Magnetic resonance Imaging
5. Computed Tomography
6. Radionucleotide Scintigraphy
7. Radioisotope Imaging

1. Conventional Radiography

Due to location of the salivary glands only superficial part of gland can be imaged with conventional radiographic technique. Conventional radiography can be used for detecting the presence of salivary stones. For visualization of parotid gland, panoramic radiography, lateral oblique and antero-posterior projections can be used. Similarly for submandibular gland panoramic, lateral oblique and occlusal radiography is used. A standard

occlusal / intraoral periapical radiograph may be placed intraorally adjacent to parotid duct to visualize a stone close to the gland orifice.

Interpretation of Conventional radiography

Sialoliths can be visualized as radiopaque stones within the gland, duct or near the orifice. However poorly calcified sialoliths and smaller stones cannot be visualized by conventional radiography. If stone is not evident with conventional radiography but clinical symptoms are present additional radiography is necessary. (7)

2. Sialography

Sialography is a technique of radiographic visualization of salivary gland following retrograde instillation of soluble contrast medium into the ducts. The technique of sialography is divide into 3 phases i.e., Preoperative phase, Filling phase, Emptying phase. Preoperative phase includes taking radiographs before the introduction of contrast medium to note the location of radiopaque obstruction and to assess the exposure parameters. Filling Phase includes introduction of contrast medium into the salivary gland. There are 3 methods of introduction of contrast medium into the gland which are simple injection technique, hydrostatic technique, Continuous infusion pressure monitored technique.) In emptying phase a sialagogue is given to the patient to facilitate removal of contrast medium from the salivary gland.(8) Sialography is mainly indicated to determine the position of salivary calculi or blockage, assessment of gland function and to determine the extent of ductal and glandular destruction.

Interpretation of Sialograph:

The normal sialographic appearance of parotid gland is like tree in winter appearance as the duct structure within the gland branches regularly and tapers gradually towards the periphery of the gland. The normal sialographic appearance of submandibular gland is so-called bush in winter as the gland is slightly smaller than parotid gland.(8) Sialographic appearances of different pathologies are given in table 1.1

Sr no	Pathology	Sialographic appearance
1.	Sialolith	Appears as filling defect in the ducts, dilation of ducts proximal to calculus or defect showing contrast medium retained behind the stone.(7)
2.	Sialodochitis	Sausage link appearance due to segmental sacculation or dilation of the main duct.
3.	Sialadenitis	Sialectasis due to dots or blebs of contrast medium within the gland.(7)(8)
4.	Sjogren's syndrome	Appears as sialectasis or the so-called snowstorm appearance due to widespread dots or blebs of contrast medium. In early stages salivary gland shows punctate (less than 1mm) and globular (1-2mm) collection of contrast agent. In later stages cavitary sialectases (more than 2mm) is noted.
5.	Intrinsic tumors	Ball in hand appearance as the adjacent ducts surrounding the tumor are stretched.(7)(8)

Table 1: Sialographic appearance of different pathologies.

3. Ultrasonography

Ultrasonic evaluation of salivary glands is usually carried using 5–12-MHz wide-band linear transducers. For evaluation of the internal structure of salivary glands frequency above 10 MHz is required. The entire ultrasonic examination of salivary glands is performed in least two perpendicular planes (10) The echogenicity, acoustic enhancement, shape, borders, calcifications and ductal patterns are assessed of the salivary gland are assessed. The vascularity of the lesion is assessed by colour and pulsed Doppler sonography.

Ultrasonography is indicated in case of salivary gland obstruction or in case of discrete or generalized swelling intrinsic or extrinsic to the salivary gland.

Interpretation of Ultrasonography

Normal ultrasonographic evaluation of salivary glands show homogeneous hyperechogenecity. (10)(11)(12) For parotid gland, facial nerve is the anatomic reference to consider the division between superficial and deep lobe. But facial nerve is rarely seen with ultrasound so ultrasonographic reference for parotid gland is retromandibular vein.

The ultrasonographic appearances of different pathologies is depicted in Table 2

Sr no	Pathology	Ultrasonographic appearance

1.	Sialolith	• Ultrasonography shows intra-ductal echogenic filling defect with posterior acoustic shadowing • Stones impacted at the duct ostium in the floor of the mouth may not be well seen sonographically.
2.	Sialadenitis (Acute)	• The gland appears enlarged and Hypoechoic(parenchyma may have a heterogeneous pattern attributable to the presence of microabscesses) • Evidence of hypervascularity on Color Doppler examination.(10)(11)
3.	Sialadenitis (Chronic)	• Multiple hypoechoic lesions against a heterogeneous background. • Hypervascularity on Color Doppler examination.
4.	Sjogren's syndrome	• In early stages the gland shows normal echogenicity. • In late stages heterogeneous echopattern with multiple round hypoechoic areas within the parenchyma(sometimes containing frank cystic changes) • In long-standing disease – appear as small and atrophic with a hypoechoic echotexture or may have a reticulated pattern.(11)
5.	Pleomorphic adenoma	• Rounded, circumscribed and hypoechoic, with distal acoustic enhancement • Color Doppler findings vary, but a peripheral "basket like" pattern of flow may be seen.(11)(12)
6.	Warthin's tumor	• Rounded or lobulated hypoechoic lesion with internal heterogeneity.
7.	Mucoepidermoid carcinoma	• Low-grade tumor – well-defined, homogenous, hypoechoic • High-grade tumor - ill-defined infiltrative margin with a heterogeneous internal architecture.
8.	Cysts	• US features of a cyst are classic (like in any other location in the body): well-defined margins, anechoic content, posterior acoustic enhancement • No evidence of internal blood flow at power Doppler or color Doppler imaging.(11)

Table 2: Ultrasonographic appearances of different salivary gland pathologies

Due to lack of knowledge of interpretation certain anatomical structures such as floor of the oral cavity may be mistaken for benign or malignant tumors. Certain normal structures such as bones, arterial wall fibrosis, air bubbles can be wrongly interpreted as deposits in the salivary gland. Sometimes lymph nodes in the glands may be treated as pathologic structures. (13)

4. Magnetic Resonance Imaging

Magnetic resonance imaging is excellent method of evaluation of salivary glands due to its high contrast resolution of soft tissues. They play an important role in the evaluation of major salivary gland diseases, particularly of neoplastic ones. In cases of large tumors (>3 cm) or of tumors located on the deep lobe of the parotid gland, MRI is superior to US in providing the delimitation of the lesion. Unlike US, MRI is also capable of showing tumors in the minor salivary glands, being a valuable complement for surgery planning. It is also helpful in demonstrating the relationship between adjacent anatomical structures.

Although MRI is an excellent imaging modality, it presents with some disadvantages such as low availability, requires good patient cooperation to avoid moving artefacts, has long acquisition time and has several contraindications (such as pacemakers, cerebrovascular cramps, or claustrophobia).

Interpretation of MRI images

MRI are most commonly used for benign and malignant tumors and also helps to differentiate the same. A low Signal intensity on T2-weighted images is more common in malignant than in benign tumors Benign tumors showed a hypointense mass on T2-weighted images. Conversely, a tumor which shows strong Signal intensity on T2-weighted images is likely benign. The best MR imaging finding for differentiating malignant from benign tumor is an ill-defined margin after intravenous contrast administration. Mostly malignant tumors show ill-defined borders. Malignant tumors typically show a diffuse or multifocal growth pattern, with infiltration of the subcutaneous tissue and the masticator space. Subcutaneous tissue infiltration appears in malignant tumors than benign lesions. Malignant tumors show perineural spread and lymphadenopathy than benign tumors. Benign tumors had a predilection for the superficial parotid lobe, with malignant lesions tending to arise in the deep lobe or in both lobes.(15) The MRI appearance of different pathologies is depicted in Table 3.

Sr no	Pathology	MRI appearance

1.	Sialadenitis	The salivary glandis often enlarged.
		• **InT1 weighted image,**
		  • Acute sialadenitis shows low signal intensity
		  • Chronic sialadenitis shows inhomogeneous low signal
		• **In T2 weighted image**
		  1. Acute sialadenitis shows high signal.
		  2. Chronic sialadenitis may show low-to-intermediate due to fibrosis.(14)

2.	Warthin's Tumor	• Unilateral non-enhancing mass • High signal intensity on T2 weighted image
3.	Pleomorphic adenoma	• Unilateral mass with post contrast enhancement • High signal intensity on T2 weighted image • Well defined borders • Does not invade surrounding tissue planes.
4.	Adenocystic or mucoepidermoid carcinoma	• Intermediate to lowsignal intensity on T2 weighted image • Ill- defined borders/margins • Diffuse growth pattern • Perineural spread.(14)
5.	Sjogren's syndrome	• Heterogeneous signal-intensity on T1- and T2-weighted images. They show multiple hypointense and hyperintense areas cause a so-called salt and pepper appearance. • In the advanced stages of primary Sjogren's syndrome, cystic changes can be found with MRI, which are thought to arise from destruction of the salivary gland parenchyma and the presence of fibrosis and fatty infiltration

Table 3: MRI appearances of different salivary gland pathologies

5. Computed Tomography

The CT scan appears as an excellent imaging modality than conventional radiography in cases of non-radio opaque sialoliths and associated salivary gland changes/pathologies. It is used as a preoperative diagnostic tool as well as post operative guide in diagnosis, treatment planning and follow up of sialoliths. It can be used in case of acute inflammatory processes and abscesses, as well as cysts, mucoceles, and neoplasia. CT depicts various structures in and adjacent to salivary glands and displays both soft and hard tissues, as well as minute differences in soft tissue densities. Glandular tissues are usually easily discernible from surrounding fat and muscle.

Interpretation of CT scans

The parotid glands appear more radiopaque than the surrounding fat but less opaque than adjacent muscles while the submandibular and sublingual glands are similar in density to adjacent muscles, they are readily identified on the basis of shape and location. The submandibular and sublingual glands are most easily identified on directly acquired contrast enhanced coronal CT scans.

Non-enhanced CT is useful in identifying small calculi within the salivary gland or duct, and is the technique of choice to look for bony erosion caused by malignant lesions. Enhanced CT is used in the staging of malignant disease that involves the salivary glands. It is useful where MRI is contraindicated for evaluation of the deep lobe, and to assess lymphadenopathy of the pharynx and neck. Also, CT is cheaper than MRI and is more readily available. Nonenhanced CT is mainly used to visualize sialoliths and enhanced scans are used to identify abscesses, cysts, and neoplasms and both nonenhanced and enhanced are used for painful masses for which one cannot exclude sialolithiasis.However, the use of CT scans should be restricted where possible because of the high dose of radiation involved. (16)(17)(18)

The CT appearance of different pathologies is depicted in Table 4.

Sr no	Pathology	CT appearance
1.	Sialolith	Appears as a dense radiopaque area in the salivary gland region.(17)
2.	Sialadenitis	Abscess cavities appear as walled off areas of lower attenuation with an enlarged gland. Contrast enhanced CT may demonstrate glandular enlargements
3.	Cystic lesions	Well circumscribed, non-enhancing (with contrast), low density areas.(16)(17)
4.	Benign tumors (e.g., Pleomorphic adenoma)	Sharply circumscribed, infrequently lobulated, round homogenous lesion that has higher density than adjacent structures.
5.	Malignant tumors (e.g.,	CT section shows irregular homogenous mass not much more dense than the

	Mucoepidermoid Carcinoma)	parenchyma CT with intravenous contrast enhancement shows the tumor as a sharply defined homogenous mass that is considerably more opaque than on CT images without contrast.(17)

Table 4: CT appearances of different salivary gland pathologies

6. Radionuclide salivary imaging

Radionuclide imaging is mainly helpful in assessing the salivary gland function and to determine the abnormalities in gland uptake and excretion. It is helps when sialography is contraindicated in cases of acute gland infection or iodine allergy. Scintigraphy is performed with 185–370 MBq (5–10 mCi) of 99mTcO4− which is intravenously administered. The uptake, excretion and concentration of the pertechnetate ion is assessed by gamma detector. A dynamic scan (anteroposterior view) is performed at 5-minute intervals for 30 minutes. Citric acid (e.g., lemon juice) is instilled into the oral cavity 20 minutes after the intravenous injection to stimulate the secretion of saliva. The TAC (Time activity curve) is used to determine the function of individual salivary gland. When the assessment of the tumor is difficult due to the physiologic uptake in the normal salivary glands, washout by stimulating the secretion of saliva is useful.

The uptake in the bilateral parotid and submandibular glands begins less than 1 minute after intravenous administration of the radionuclide and increases over time. The uptake in the parotid glands is equal to or greater than that in the submandibular glands. The sublingual glands are not visible, though the reason is unknown. After the stimulation of saliva secretion, the uptake rapidly declines in all four glands and subsequently rises again. The percentage of washout is calculated using the counts at the maximum uptake and those at the minimum uptake seen after the stimulation of saliva secretion in each gland. The washout (%) is 50% or higher in the normal salivary gland.

Radionucleotide salivary imaging is indicated in cases of ductal obstruction, sialolithiasis, gland aplasia and Sjogren's syndrome.(19)

Table 5 shows radionucleotide imaging of different salivary gland pathologies.

Sr No	Pathology	Apperance
1.	Acute Sialadenitis	Shows increased uptake of 99mTcO4- It shows reduced or no response to stimulation of salivary secretion
2.	Chronic Sialadenitis	Shows decreased uptake of 99mTcO4- Reduced or no response to stimulation of salivary secretion.(19)
3.	Pleomorphic adenoma	99mTcO4- is not taken up by the pleomorphic adenoma
4.	Warthins tumors and oncocytomas	99mTcO4- is taken up by the solid component of the tumors and is not eliminated after the stimulation of saliva secretion. They appear as areas of increased activity on static images.
5.	Sjogren's syndrome	All salivary gland show decreased uptake and poor response to stimulation of saliva secretion 20minutes after administration.(19)

Table 5: Radionucleotide imaging of different salivary gland pathologies

7. Radioisotope imaging

FDG (Flurodeoxyglucose) PET is beneficial in determining the focal lesions, staging and clinical management of salivary tumors. In case of highly-malignant tumors requiring aggressive treatment, FDG-PET provides information about systemic metabolism which is very useful for the determination of lesions and their treatment strategy. Therefore, PET scan is essential before the initiation of treatment and for patient follow-up It is also helpful in detection of local involvement, regional lymph node metastasis, distant metastasis, and dissemination for the clinical staging and restaging. Sometimes it is useful in the detection of an incidental cancer. (19)(20)

In this technique FDG is intravenously administered at a dose of 5–12 mCi and radiographs are taken 60–90 minutes after administration to visualize distribution. The accumulation of FDG is visually and semi-quantitatively assessed using the standardized uptake value (SUV). SUV is the ratio of uptake to the injected dose per unit body weight.

Based on the results of FDG uptake and based on the comparison of the results of SUVmax alone, differentiation of benign from malignant parotid tumors is not possible. FDG uptake is more intense in benign tumor than malignant however, benign tumors, such as Warthin's tumor and pleomorphic adenoma, also show high FDG uptake. Some studies suggest that the differentiation of benign from malignant salivary tumors is possible with the use of indices such as dual-time-point (DTP) imaging and tumor volume, in addition to SUVmax. Use of 4′-[methyl-11C]-thiothymidine (4DST) PET, provides cell proliferation imaging capable of demonstrating intense uptake in parotid carcinoma and Warthin's tumor, but no uptake in parotid pleomorphic adenoma. (21)

Other disadvantages of PET include high radiation dose, final images are not disease specific and it provides no indication of salivary gland anatomy or ductal architecture. Due to these reasons nowadays, PET is

combined with computed tomography (PET/CT). This has increased the diagnostic accuracy by compensating for PET disadvantages, including poor spatial resolution and lack of anatomic information. Also, PET combined with magnetic resonance imaging (PET/MRI) has recently emerged. Table 6 shows radioisotope imaging of different salivary gland pathologies.

Sr no	Pathology	Appearance
1.	Sialadenitis	Diffuse, increased uptake.
2.	Pleomorphic adenoma	Increased FDG uptake (hypermetabolic)
3.	Warthin tumor	Increased FDG uptake (hypermetabolic)
4.	Low-grade malignant tumors	They have relatively low glucose metabolism and appear "cold" (hypometabolic) on FDG-PET imaging.(20)

Table 6: Radioisotope imaging of different salivary gland pathologies

II. Conclusion

Salivary gland imaging plays an important role in the diagnosis of salivary gland disease. Various salivary gland imaging modalities include Plain film imaging, Sialography, Ultrasonography, Magnetic resonance imaging, Computed tomography, Radionuclide salivary imaging and Radioisotope imaging. Ultrasonography should be considered as a primary imaging modality for salivary gland pathologies. Few salivary gland pathologies have a characteristic appearance on the radiographs. Sialography of the salivary glands should done whenever and wherever necessary. CT or MRI should be indicated in diagnosis of salivary gland tumors, large salivary gland stones/ pathologies. Thus, accurate understanding and interpretation of radiograph is necessary for understanding the pathology and proper treatment planning.

References:

[1]. Whelton H. Introduction: the anatomy and physiology of salivary glands. Saliva and oral health. 1996:1-9.
[2]. Krishnamurthy S, Vasudeva SB, Vijayasarathy S. Salivary gland disorders: A comprehensive review. World Journal of Stomatology. 2015 May 20;4(2):56-71.
[3]. Riyaz MA. Diagnostic Salivary Gland Imaging-A Review. Integrative Journal of Medical Sciences. 2021;8.
[4]. Rastogi R, Bhargava S, Mallarajapatna GJ, Singh SK. Pictorial essay: Salivary gland imaging. Indian Journal of Radiology and Imaging. 2012 Oct;22(04):325-33.
[5]. Pawar A, Kale L, Bansode A. Diagnostic imaging of salivary glands: a review. International Journal of Current Research,.2019 June.11, (07), 5254-5259.
[6]. Bhaumik J. Imaging the Major Salivary Glands: A Review. Adv Dent & Oral Health. 2018; 8(4): 555745.
[7]. Textbook of dental and maxillofacial radiology by Freny Karjodkar (2^{ND} edition)
[8]. Essentials of dental radiography and radiology (Fourth edition) by Eric Whaites
[9]. Kushner DC. Sialography of salivary gland tumors with fluoroscopy and tomography. Japanese Journal of Radiological Technology. 1978 Sep 1;34(3):332.
[10]. Lavanya R, Chaitanya NC, Waghray S, Babu DB, Badam RK. Diagnostic and therapeutic ultrasound in dentistry. J Dent Orofacial Res2015. 2015;11:32-6.
[11]. Shankar VN, Praveena V, Amingad BB. Ultrasonography of salivary gland: A pictorial review. Journal of Oral and Maxillofacial Surgery, Medicine, and Pathology. 2014 Jan 1;26(1):61-7.
[12]. Bialek EJ, Jakubowski W, Zajkowski P, Szopinski KT, Osmolski A. US of the major salivary glands: anatomy and spatial relationships, pathologic conditions, and pitfalls. Radiographics. 2006 May;26(3):745-63.
[13]. Białek EJ, Jakubowski W. Mistakes in ultrasound examination of salivary glands. Journal of Ultrasonography. 2016 Jun;16(65):191.
[14]. Nishimura DA, Carneiro AL, Costa K, de Campos WG, de Oliveira JX, Arita ES. Magnetic resonance imaging of salivary glands: a literature review. Clinical and Laboratorial Research in Dentistry. 2019 Mar 13.
[15]. Christe A, Waldherr C, Hallett R, Zbären P, Thoeny H. MR imaging of parotid tumors: typical lesion characteristics in MR imaging improve discrimination between benign and malignant disease. American journal of neuroradiology. 2011 Aug 1;32(7):1202-7.
[16]. Burke CJ, Thomas RH, Howlett D. Imaging the major salivary glands. British Journal of Oral and Maxillofacial Surgery. 2011 Jun 1;49(4):261-9.
[17]. Dhameja M, Singla V, Dhameja K, Singla N. Diagnostic Imaging of the Salivary Glands-A Review. International Journal of Contemporar y Medicine Surgery and Radiology. 2016;1(1):12-5.
[18]. Thoeny HC. Imaging of salivary gland tumours. Cancer Imaging. 2007;7(1):52.
[19]. Nakayama M, Okizaki A, Nakajima K, Takahashi K. Approach to diagnosis of salivary gland disease from nuclear medicine images. In Salivary Glands-New Approaches in Diagnostics and Treatment 2017 Dec 20. IntechOpen.
[20]. Larson CR, Wiggins RH. FDG-PET imaging of salivary gland tumors. InSeminars in Ultrasound, CT and MRI 2019 Oct 1 (Vol. 40, No. 5, pp. 391-399). WB Saunders.
[21]. Minamimoto R. Proliferation PET/CT Imaging of Salivary Gland Tumor. Diagnostics. 2021 Nov;11(11):2065.

Dr Rucha Pandharipande, et. al. "Current Concepts and Interpretation of Salivary Gland Imaging – A Review." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 21(04), 2022, pp. 01-06.