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REVIEW ARTICLE

SALIVARY GLAND IMAGING- AN OVERVIEW

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ABSTRACT

A variety of conditions including obstructive, inflammatory, infectious and neoplasms affect the salivary glands. On clinical examination, nodal masses, peripheral nerve schwammomas, and masseteric hypertrophy may mimic tumors of salivary glands. This renders the spectrum of imaging and diagnostic procedures wide to attain an appropriate diagnosis. Also, imaging serves as an immediate and preliminary choice of investigation that helps in delineating the extent of the lesion and invasion of adjacent cervical spaces, skull base, mandible, nerves and meninges in the cases of salivary gland tumors. The choice of imaging modality remains cryptic till date owing to the advancements in the field of imaging from the contingency on plain film radiography to exquisite techniques like magnetic resonance imaging, tomography and nuclear imaging. With the advances in the imaging modalities the ease of identification of pathologies and their differentiation from the physiological and morphological alterations has been increased. The review attempts to provide a keynote on the evolution and availability in the field of imaging for the diagnosis of salivary gland pathologies.

INTRODUCTION

Salivary glands are exocrine glands that produce saliva. Three pairs of major salivary glands namely, parotid, submandibular and sublingual glands and numerous minor salivary glands scattered throughout the oral cavity, nasopharynx and tracheobronchial tree are present in the human stomatognathic system (Taneja, 2015). The parotid gland is the largest salivary gland and is composed of adipose and glandular tissues in nearly equal proportions. The submandibular gland is the second largest salivary gland and is located in the floor of the mouth adjacent to the posterior body of mandible along the free edge of the mylohyoid muscle. The amount of adipose tissue is relatively lower than that of parotid gland (Rastogi, 2012). Sublingual gland is the smallest major salivary gland. It lies submucosally adjacent to the anterior mandible in parasymphyseal location. A variety of disease processes affect the salivary glands, including inflammatory, systemic, obstructive and neoplastic. This renders the spectrum of imaging and diagnostic procedures wide to attain an appropriate diagnosis. With the advances in the imaging modalities the ease of identification of pathologies and their differentiation from the physiological or morphological alterations and pathologies in the adjacent cervical spaces has been increased.

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The main investigations used in the imaging of salivary glands include; plain film radiography, sialography, ultrasound, magnetic resonance imaging, radioisotope imaging, computed tomography. The following review provides a kernel about available and advanced imaging modalities in salivary gland imaging.

Plain film Radiography

Projection radiography or plain film radiography is the preliminary and principal method in the radiographic examination of the salivary glands and may provide information to preclude the use of sophisticated imaging techniques. The radiographic imaging should include both intraoral and extraoral images to demonstrate the entire region of the gland. Projection images are useful when the clinical impression, supported by a compatible history, suggests the presence of sialoliths (stones or calculi). Sialoliths may be multiple at different locations. It is expedient to decrease the usual exposure by about half to avoid overexposure of the sialoliths. This technique is limited by the fact that 20% of the sialoliths of the submandibular gland 40% of the sialoliths of the parotid gland are not well calcified, rendering them radiolucent as stated by Feuz (1993) (Rose SS, 1951) and not visible on projection images. These sialoliths are rarely found in the sublingual glands. Panaromic and posterioanterior skull radiographs may demonstrate bony lesions, eliminating salivary pathoses from differential diagnosis. Unilateral or bilateral, fuctional or congenital hypertrophy of the masseter muscle may clinically mimic a salivary gland tumor. An extraoral image may demonstrate a deep antegonial notch, overdeveloped mandibular angle, exostosis on the outer surface of the angle in cases of masseter hypertrophy (Dr. Saraswathi Gopal *et al*, 2017). Plain film radiography includes occlusal radiographs, panaromic radiographs, lateral oblique projection, posterio anterior views and skull projections.

Intra oral Radiography

Sialoliths in the anterior two thirds of the sub mandibular duct are typically imaged with a cross sectional mandibular occlusal projection. The posterior portion of the duct may be demonstrated with an over the shoulder occlusal projection view, where the directing cone is placed on the shoulder and the central ray is directed in an anterior direction through the angle of the mandible, with the patient's head rotated back and tilted to the unaffected side. Parotid sialoliths are more difficult to demonstrate than the submandibular variety owing to the tortuous course of stensen's duct around the anterior border of the masseter and through the buccinator muscle. Only sialoliths anterior to the masseter muscle can be imaged on the intra oral image. To demonstrate sialoliths in the anterior part of the duct, an intra oral image receptor is stabilized with a holder inside the cheek, as high as possible in the buccal sulcus and over the parotid papilla. The central ray is directed perpendicular to the center of the receptor.

Extra oral radiography

A panaromic projection frequently demonstrates sialoliths in the posterior duct or reveals intraglandular sialoliths in submandibular gland if they are within the image layer. The image of most parotid sialoliths is superimposed over the ramus and body of the mandible at the level of or just superior to occlusal plane, making olique lateral radiographs of the mandible of limited value. To demonstrate sialoliths in the submandibular gland, the lateral projection is modified by opening the mouth, extending the chin and depressing the tongue with the index finger; this improves the image of the sialolith by moving it inferior to the mandibular border (Oscar Hasson, 2010). A posterioanterior skull projection with the cheeks puffed out may move the image of the sialolith free of adjacent bone, rendering it visible on the projected image. This technique may also demonstrate intraglandular sialoliths that may be obscured during sialography.

Sialography

The injection of radiopaque contrast media into the salivary glands as an adjuvant to the clinical evaluation has long been regarded as a valuable aid to diagnosis. Sialogram as a diagnostic measure was first carried out in 1925 when Barsony described a method of outlining the parotid duct, using 20 per cent potassium iodide (Rose, 1951). This medium was proved to be an irritant and the technique was relinquished. Exordium of lipiodol usage provided a scope to this investigation. R. T. Payne (1931), published the first of his classical series of papers on this subject, using a glass pipette with 1/2 to 1 ml of lipiodol very slowly into the appropriate duct orifice until discomfort was complained. An X-ray is taken immediately with the instrument in position. This method of sialography gave a clear picture of the main duct system, and often extended into the finer ducts and acini when the injection was complete. The use of neohydriol fluid, has obviated most of the early technical difficulties, as its low viscosity allows greater ease and speed of injection with the minimum of effort. It has been stated that water-soluble radiopaque contrast media should be used because of their low viscosity and they show no tendency to break into globules (Rose, 1951). With the advancement in technology and the development of endoscopic techniques for the diagnosis and treatment of obstructions in the ducts of the salivary glands, sialography has gained an important place as one of the tools available for the evaluation of salivary gland obstructions. In most cases, modern sialography is not time-consuming and the refinement of intravenous catheters has made the procedure painless and easy to perform (Oscar Hasson, 2010).

Sialographic studies can demonstrate important and interesting pathologic features of the involved salivary glands. The anatomy of the duct can be displayed, revealing its form as narrow or large, the presence of secondary branches leaving the main duct, and the presence of accessory glands or sialolithiasis, including their dimensions, number, and positions. Another advantage of this technique is its ability to reveal the presence of internal duct strictures, especially in the parotid gland, which always escape detection with radiography and sometimes with ultrasonography (Rose, 1951). Obstruction of salivary glands is a common pathologic finding that affects a large number of patients. The incidence of calculi in the parotid is as low as 2% of salivary stones. These calculi are common in the submandibular gland duct owing to its tortuous course, mineral content of the saliva, mucinous nature of the saliva and the anatomical positioning of the gland. The contraindications for the procedure include the proximal presence of a sialolith within the duct for the calculi or the stone may be displaced distally and the presence of an internal stricture. An allergy to the contrast material (usually iodine) is also a contraindication. With the introduction of minimally invasive endoscopic procedures for salivary gland obstructions, sialography has re-emerged as an important gland examination, disclosing important anatomic and pathologic information about the gland before sialoendoscopy.

Marchal and Dulguerov (2003) reported a preference for using sialoendoscopy, rather than sialography, as a primary tool for the diagnosis of salivary gland obstruction. They reported that the injection of contrast material could push sialoliths further back into the duct, complicating endoscopic removal of the sialolith (Oscar Hasson, 2010). Magnetic Resonance Sialography (MR sialography) is a noninvasive method for evaluating the ductal structures of the major salivary glands. While the technique and its applications have evolved greatly from its initial description in the mid-1990s, it remains rooted in the simple concept that stationary fluid, such as saliva, has intrinsic high T2 signal intensity, obviating instillation of contrast material to "opacify" the salivary ducts (Varghese JC, 1999). MR sialography offers several advantages over conventional or digital sialography, including its non-invasive technique, lack of the need for contrast media, lack of ionizing radiation, independence from an experienced operator, its concomitant evaluation of the salivary glandular parenchyma, and acute sialadenitis not being a contraindication for imaging. Varghese *et al* (1999) claimed that the invasiveness of sialography is a drawback of the procedure. They compared the use of magnetic resonance sialography with that of conventional sialography in 49 patients and concluded that magnetic resonance sialography is sufficiently sensitive in cases of tight strictures but not sensitive enough when salivary stones are present.

Ultrasonography

Ultrasonography is widely accepted as the first imaging method for assessment of lymph nodes and soft-tissue diseases in the head and neck, including major salivary glands (C.J. Burke *et al*, 2011). Ultrasonography is a useful technique for the assessment of superficial masses of the parotid and submandibular glands and is increasingly becoming the method of choice for initial evaluation of the salivary gland masses and inflammatory disease of the salivary glands (1994). Ultrasound allows detection of sialoliths, differentiation of benign from malignant masses, distinction of intraglandular lesions from extra glandular lesions and in the confirmation of diagnosis of abscesses and sialectasia. Although ultrasound has certain disadvantages in its inability to evaluate deep parotid masses, lack of specificity for cystic lesions and the relation of a tumor to the facial nerve, the technique also provide with advantages like being inexpensive, safe due to the non invasive nature and doesn't involve the use of ionising radiation or contrast medium. As the head and neck region has a complex anatomic structure, a sound knowledge of sonographic anatomy and spatial relationships is crucial for reliable performance of the examination. Also, knowledge of the sonographic features of the most common diseases in this area is a requisite (Ewa, 2006). Both the parotid and submandibular glands appear homogeneously hyperechoic on High Resolution Ultrasonography (HRUS), and retromandibular vein can be noted within the parotid gland.

It is performed by a high frequency linear (7-10 MHz) transducer. It helps in differentiating intra parotid nodes from true intraparenchymal lesions, picking soft calcifications/diffuse lesions and detecting major ductal dilatation with intraductal calculi. In acute inflammation, salivary glands are enlarged and hypoechoic. They may be inhomogeneous; may contain multiple small, oval, hypoechoic areas; and may have increased blood flow on ultrasonography. In chronic inflammation, salivary glands are normal sized or smaller, hypoechoic, and inhomogeneous and usually do not have increased blood flow on ultrasonography. Ultrasonographic features of sialolithiasis include strongly hyperechoic lines or points with distal acoustic shadowing, which represent stones. In symptomatic cases with duct occlusion, dilated excretory ducts are visible. When the ultrasonographic appearance of most common benign tumors of salivary glands is analyzed, many common features may be found, but definitive differential diagnosis is usually not possible with this technique which is of prime concern in differentiating benign from malignant tumors.

Ultrasonography is also used in many units as the primary imaging tool for assessing suspected stone disease and abscesses. Its limitations include an inability to evaluate deep parotid masses (because they are obscured by the mandible), parapharyngeal extension, retropharyngeal and deep neck adenopathy, and the extent of an intracranial or skull base mass. It therefore acts as a guide to the choice for further imaging to find out whether a lesion is locally invasive, to show the extent of large tumours, or to assess whether a lesion is likely to be malignant (Burke, 2011). It helps in differentiating cystic from solid lesions and also aids in guiding the exact site of Fine Needle Aspiration Cytology (FNAC) in suspected salivary gland lesions. When combined with color Doppler imaging, it helps in assessing the vascularity and nature of the lesion (C.J. Burke *et al*, 2011). The failure of gray-scale sonography to depict some cancers of the salivary glands raised interest in color Doppler imaging as an additional tool for tumor differentiation. A number of color Doppler criteria have been established to distinguish benign and malignant nodules, specifically (1) grade of intra tumor vascularity, (2) pattern of vascular supply, and (3) pulse-wave Doppler findings. In the salivary glands, the extension of intratumoral flow is much more relevant in malignant than in benign tumors, and the arterial velocity can be markedly higher (Carlo Martinoli, 1994).

Magnetic Resonance Imaging

Magnetic Resonance Imaging (MRI), because of its multiplanar capability and higher soft tissue resolution, is advanced in demonstrating the extent of lesion and their perineural/meningeal spread. These imaging studies are accomplished to delineate the anatomy and extent of the lesion usually after an intravenous injection of the contrast medium. T1-weighted imaging of parotid glands lends better tissue contrast because of presence of adipose cells within the stroma, yielding high T1 signals. T2- weighted and post contrast fat-suppressed imaging with T1 weighting is also recommended. Because fat also has high T2 signal on fast spin echo imaging, fat suppression on T2-weighted images helps to bring about tissue specificity. Axial and coronal views are generally obtained. Non enhanced T1-weighted images combined with non fat-suppressed fast spin echo (FSE) T2-weighted images are optimal for delineation of lesions and prediction of the nature of parotid gland pathology. T1-weighted and T2-weighted phase–contrast imaging of parotid masses allows greater tissue–lesion contrast, but there is no advantage in lesion detectability (Rastogi, 2012 and Shah, 2011).

Diffusion weighted (DW) images and Gadolinium enhanced dynamic MR (Gd MRI) imaging have proven to be very useful in differentiating benign from malignant tumors. DW images can be used to calculate apparent diffusion coefficient (ADC) values, which are different for different salivary gland tumors. Gd MR with dynamic imaging using 120 seconds as cut off for time to peak enhancement and 30 % wash out ratio can differentiate benign and malignant tumors as the latter take less time for peak enhancement and show rapid wash out. Plateau type of time–intensity curve in dynamic Gd MR coupled with low ADC values is also highly suggestive of malignancy (Rastogi, 2012).

Computed Tomography (CT)

Unenhanced computed tomography 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 and chest. It is useful where MRI is contraindicated for evaluation of the deep lobe, and to assess lymphadenopathy of the pharynx and neck. Its use however, should be restricted where ever possible because of the high dose of radiation involved. The technique is cost effective when compared to MRI.1 In a study conducted by R. Nick Bryan and Robert H. Miller (1981) it was concluded that the overall sensitivity of CT in detecting salivary gland lesions approached 100%. This figure, however, must be tempered by the bias of the sample Since only those lesions that had surgical exploration, biopsy, on obvious clinical diagnosis were included, more subtle on transient lesions might well be missed by the technique. However, it does seem that the technique is extremely sensitive for neoplasia. Also, in 75% of cases, CT determined the anatomic relation of the lesion to the facial nerve, information that may be helpful to the surgeon (Bryan, 1982). While sensitivity was quite good, specificity of the CT scan alone, without clinical information, was only about 75% when categorizing lesions as to benign neoplasia, malignant neoplasia, on diffuse on focal inflammatory disease with or without calculi. When combined with clinical information and laboratory findings, the overall specificity was 90%. Hence, computed tomography with a high-resolution CT scanner can be the initial radiographic procedure of choice in evaluating salivary gland masses, particularly if neoplasm is the prime consideration (Bryan RN,1982). CBCT sialography has rarely been reported. Drage and Brown (2009) were pioneers in reporting cases of CBCT sialography. They concluded that CBCT sialography was superior to conventional sialography and explained that 3D reconstruction could be performed and then viewed from any direction and in any slice thickness, and from which cross-sectional slices might be obtained in any direction. This might prove useful for demonstrating areas of complex anatomy (Drage, 2009).

Radionuclide Imaging

It is a rarely used technique for salivary gland imaging. It is generally assumed that in man pertechnetate is concentrated and secreted into saliva by the cells of the striated ducts. However, unequivocal evidence demonstrating these cells to be the site of pertechnetate transfer is still lacking (Loutfi I, 2013). It is assumed that Sodium pertechnetate (Tc[99]) is actively concentrated and secreted by salivary gland cells while it is not taken up by majority of neoplastic lesions, hence the latter appear as cold spots. Warthin's tumor is an exception to the rule and appears as a hot spot. Actively dividing cells take up Gallium67; hence it is useful in detecting diffuse inflammatory/neoplastic processes such as sarcoidosis and lymphoma. Salivary scintigraphy provides images of the parotid and submandibular glands. In addition, physiologic intervention by administration of a sialogogue such as lemon juice provides information on the patency of the salivary ducts and on the overall functional integrity of the system. Salivary scintigraphy has been useful for investigation of multiple diseases affecting the salivary glands. In Sjogren's syndrome, pertechnetate imaging can gauge the severity of salivary gland involvement, which may not be accurately reflected by the symptoms. In other clinical situations, such as iatrogenic irradiation of the salivary glands for therapy of head and neck tumors or radioiodine treatment of thyroid cancer, salivary scintigraphy helps assess functional damage and monitor recovery in these patients. Recently, salivary scintigraphy has been refined toward providing quantitative information on changes in gland function after parenchymal insult, which is either inflammatory or radiation induced (Loutfi, 2003). Positron emission tomography (PET) imaging using 2deoxy2[18F] fluoro d glucose (FDG) can be used to differentiate benign from malignant tumors of the salivary glands as the former appear as cold spots with the exception of Warthin's tumor and oncocytoma (Rastogi, 2012).

Conclusion

Advances in imaging have led to improved diagnosis of diseases of the major salivary glands. High resolution ultrasonography should be the first screening imaging tool followed by sialography, if required. CT is the mainstay of imaging in sialolithiasis while MRI is more optimal for neoplastic processes with associated invasion. CT and MRI are equally good in imaging of the cystic and inflammatory lesions in general and abscesses in particular. Radionuclide imaging with advances in scintigraphy provides quantitative information on changes in gland function after parenchymal insult, which is either inflammatory or radiation induced. However, the algorithm for imaging the salivary glands depends on the clinical situation with which the patient presents to the clinician.

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