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REVIEW ARTICLE

DIAGNOSTIC IMAGING OF SALIVARY GLANDS: A REVIEW

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ABSTRACT

Salivary glands are the first organs of digestion secreting their digestive juices into the oral cavity. Parotid, submandibular, and sublingual glands are the major paired salivary glands in the decreasing order of their size. The imaging is directed to the major salivary glands. Although a lot of refinement of the older techniques and advancement in terms of newer techniques have happened in this field of imaging studies, but it is always better to learn and understand each and every technique available for this special group of disorders. This article provides an overview of various diagnostic techniques available.

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INTRODUCTION

The human Salivary glands are the first organs of digestion secreting their digestive juices into the oral cavity (Rastogi, 2012). Saliva prevents desiccation of the mucous membrane and plays important role in early phase of digestion by moistening dry food, facilitating its passage into the oropharynx, which further helps in deglutition. Saliva contains enzymes that initiates the digestive process & number of immunoglobins important in oral homeostasis (Del, 2015). Parotid, submandibular, and sublingual glands are the major paired salivary glands in the decreasing order of their size (Rastogi, 2012). In addition, multiple small minor salivary glands are noted randomly distributed in the upper aero digestive tract, including paranasal sinuses and Para pharyngeal spaces. The common clinical indications of salivary gland imaging are pain and swelling (Del Bal so,). [1]Evaluating the abnormality weather, it is ductal, parenchymal or physiologic origin (Del Bal so,). A variety of disease processes affect the salivary glands, categorized into the inflammatory, systemic, obstructive, congenital and neoplastic. Imaging plays an important role in detection, diagnosis and differentiation of malignant lesions from benign (Taneja, 2015).

Diagnostic Imaging is useful in identifying the masses of salivary glands and also in differentiating them from the masses/ pathologies of adjacent cervical spaces, especially para pharyngeal, masticator, and submental spaces and mandibular lesions (Rastogi, 2012). Imaging helps in delineating the extent of the lesion and invasion of adjacent cervical spaces, skull base, mandible, and nerves/meninges (Rastogi, 2012). The traditional imaging modalities include plain radiography and sialography. With the advent of modern imaging methods like high resolution ultrasound with color Doppler, contrast enhanced CT, MRI and MR sialography, the imaging has become increasingly reliable in making a confident diagnosis and the functional status of the gland (Taneja, 2015). Although a lot of refinement of the older techniques and advancement in terms of newer techniques have happened in this field of imaging studies, but it is always better to learn and understand each and every technique available for this special group of disorders (Mukesh Dhameja, 2016). Further varied techniques are used to learn information on salivary gland structure and function, anatomical variations and space-occupying lesions within the glands. Thus, the dissertation covers the awareness and understanding of various imaging techniques, as applicable in the field of salivary gland pathologies, shall be an important aspect of a medical professional in order to reach to a clear understanding of the pathology, making a definitive diagnosis

and drawing a precise road map towards a successful treatment and a better prognosis.

Plain-Film Radioghraphy: This is the simplest, oldest, and cheapest way of studying the salivary glands. It is useful in detecting ductal calculi, calcifications (as in hemangioma and lymph nodes), and adjacent osseous lesions. Only one-fifth of the salivary ductal calculi are radiolucent. Parotid gland radiography requires posteroanterior projection with extended chin, open mouth, and cheeks blown out to delineate Stenson's duct lesion. Submandibular gland radiography requires posteroanterior and ipsilateral oblique projection with extended chin, open mouth, and tongue depressed by patient's finger.
Since the salivary glands are relatively located superficially (Greenberg, 2003 and Yuasa, 1997), a radiographic image can be made with a conventional radiographic technique. Plain film radiography is indicated in the cases of obstruction of salivary gland causing symptoms like pain and swelling of the affected gland in order to possibly visualize radiopaque salivary gland or duct stones. Following are some of the views for each type of major salivary gland:

Parotid Gland: Antero-Posterior (AP), Lateral Oblique and Panoramic view (OPG).

Parotid Duct: Occlusal film placed intraorally adjacent to the parotid gland duct and opposite to maxillary molars would help to visualize any stone near the gland orifice. (Note: is technique will not capture the entire parotid gland).

Submandibular Gland and Duct: Occlusal, Lateral Oblique and Panoramic view (OPG).

Xeroradiography

This technique is not used these days. It was first described by Boag in 1973 for imaging of the human body. is technique employs a thin layer of photoconductive selenium alloy deposited on an aluminum substrate, which is subsequently electro- statically positively charged, stored with in a cassette, and used as a radiographic image. It has been found useful in imaging of the salivary glands. Specific feature like edge contrast enhancement especially helps in detection of radiolucent sialoliths. Plain film radiography is typically the appropriate starting point for imaging the major salivary glands from a cost- benefit point of view. It can demonstrate sialoliths and the possible involvement of adjacent structures. Because obstructive and associated inflammatory conditions are the most common disorders and primarily involve the ductal system, conventional sialography is the most appropriate imaging modality.

It has the potential to identify unrelated pathoses in the area of the salivary glands that may be mistakenly identified as salivary gland disease, such as resorptive or osteoblastic changes in adjacent bone causing periauricular swelling mimicking a parotid tumor. Plan film radiographs are useful when the clinical impression, supported by a compatible history, suggests the presence sialoliths (stones or calculi). Such an examination should include both intraoral and extraoral images to demonstrated the entire region of the gland. Several sialoliths may be present at various locations.it is expedient to use about half the usual exposure to avoid overexposure of the sialoliths. However, this technique is limited by the fact that 20% of the submandibular gland and 40% of those of the parotid gland are not well calcified and therefore are radiolucent and not visible in plain films. This radiography is a fundamental part of the examination of the salivary glands and may preclude the use of more sophisticated and expensive imaging techniques.

Sialography

Sialography was introduced simultaneously and independently by BARSONY (1925), USLENGH (I1925) and CARLSTEN (1926), a contrast medium of high viscosity being used (Lipiodol or iodized oil). Sialography is the retrograde injection of an iodinated contrast agent into the ductal system of a salivary gland. Sialography is a simple, painless procedure normally performed in a matter of minutes. The patient's past, present should be verified that sialography is the appropriate imaging modality. Any allergies to radiographic contrast agents, autoimmune disorders and medication, when the evaluation is being performed bilaterally salivary enlargement caused by autoimmune disorders. Fig 1

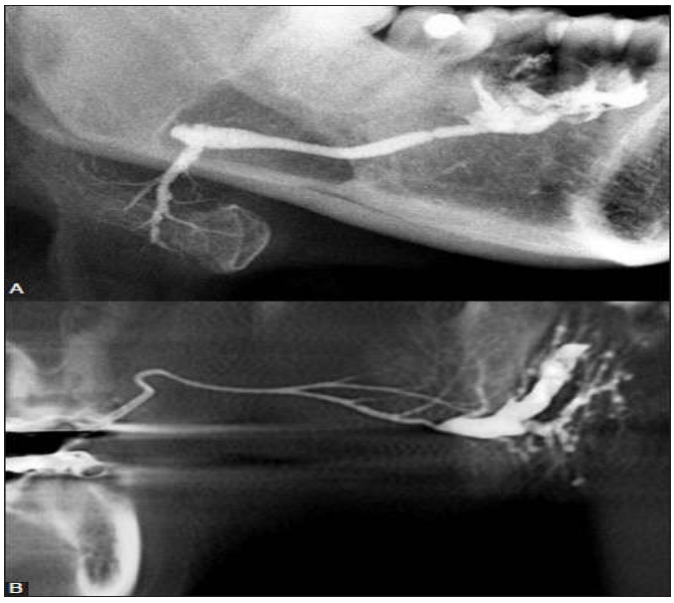

Fig. 1. Conventional sialography of submandibular (A) and parotid glands (B) showing ductal system (ref: INDIAN J RADIOL IMAGING. 2012 OCT-DEC; 22(4): 325–333.)

Armamentarium of Sialography

- Sialography catheters
- Lacrimal probes
- Iodinated contrast agent
- Dental cotton rolls
- Contrast agents

Contrast Agents

- The contrast agents used in sialography are either fat-soluble or water-soluble agents, containing approximately 37% iodine.

Fat-soluble (oily) media: Fat soluble or oily contrast agents that have been used in sialography include ethiodol, Lipiodol, and Pantopaque. Ethiodol (ethiodized poppy seed oil) is probably the most widely used sialographic contrast agent. Its lower viscosity, thereby permitting easier filling of smaller ducts (Som, 1984). Ethiodol is not diluted by saliva or

absorbed across the glandular mucosa, overall was a contrast agent of choice when sialography was the only imaging modality available.

Water-soluble agents: Most commonly used agents are the angiographic dyes, these dyes are low viscosity, containing upto 28 & 38% of iodine. Sinografin (diatrozoate meglumine and iodipamide meglumine injection) is one of the water-soluble dyes useful in sialography, it is highly viscous agent with a high iodine content (38%) (Som, 1984). Sinografin provides optimal visualization of the major ductal elements and is currently the contrast agent of choice.

Injection Techniques in Sialography

- Hydrostatic injection
- Distention techniques
- Hand injections

Phases of Sialography

Ductal Phase

- This phase starts with the injection of the contrast and terminates once the parenchyma starts to become hazy, reflecting the onset of acinar opacification.
- PAROTID GLAND: the ductal phase of the normal parotid sialograms should demonstrate the main duct to be of uniform caliber and extends from the ductal orifice to the hilus of the gland. The Intraglandular portion of the parotid system should demonstrate a progressive arborization of the secondary and tertiary ducts, which gives a configuration as a "leafless tree".
- Six patterns of Intraductal branching have been noted in the parotid gland (Hettwer, 1986).

Acinar Phase

- The second phase of sialography, commences with the completion of ductal opacification and ends when there is a generalized, increased density to the gland. It is intended to demonstrate the presence of Intraglandular or extra glandular masses.

Evacuation Phase

- The evacuation phase is useful for providing an estimate of the secretory function of the gland as well as demonstrating or accentuating ductal pathology. The phase is divided into two subphases, first subphase is evaluation of the nonstimulated evacuation of the ductal system with observation period of over 1 minute.
- A normal functioning, non-obstructed gland should clear nearly all of the injected contrast. The second phase is evaluation of the glandular response to stimulation using a sialagogue such as lemon drops or juice on tongue and monitoring the clearing of contrast from the gland.
- Nonclearing or incomplete clearing of the gland may be due to a stricture, a sialoliths or both or an underlining pathology.

Indications of Sialography

- Acute obstructive Sialadenitis is the result of ductal obstruction due to sialoliths or strictures. Sialolithiasis frequently occurs in the dep segments of submandibular duct.
- Chronic obstructive Sialadenitis involves primarily the parotid duct and is result of recurrent, ascending infections resulting in both ductal strictures and dilatation. These strictures often facilitate the formation of stone, resulting in an acute obstruction in a deformed duct.
- Autoimmune Sialadenitis is the result of autoimmune processes and involves primarily the secondary duct of parotid gland.
- Sialosis (benign parotid hypertrophy) spares the ductal system and involves the acinar tissues of the parotid gland. It has been associated with a number of endocrine and nutritional aberrations.
- Obstructive Sialadenitis important information that can be provided by sialography in the evaluation includes:
- Differentiation between Radiodense sialoliths and other calcific densities.
- Demonstrate of the presence and location of an obstructing stones.
- Difference between radiolucent sialoliths or stricture.
- Demonstration of the presence of a stricture impending the movement of a sialoliths.
- Evaluation of ductal system who has recently passed a stone determine whether any potentially obstructing stones are present.
- Evaluation of the ductal system in gland with chronic Sialadenitis to determine whether removal of gland is indicated.
- Differentiation between recurrent parotid enlargement due to chronic Sialadenitis, sialosis or autoimmune conditions involving the gland.

CT Sialography

- Sialography can be performed in conjunction with CT, termed as CT sialograms. CT sialography was initially introduced as a mean of enhancing the visualization of salivary masses on early CT scanner. It is used for occasional cases, primarily those involving dense parotid glands in which a mass is strongly suspected clinically but cannot be demonstrated on routine contrast enhancement CT study.

High-Resolution Ultrasonography (hrus): Ultrasonography (USG) is helpful to visualize superficial structures like the parotid and submandibular glands, although the deep portion of the parotid gland is difficult to visualize because the presence of bony ramus which lies over the deep lobe. Ultrasonography is also helpful to differentiate between intra glandular and extra glandular masses as well as between solid or cystic mass (Yuasa, 1997 and Escudier, 2005). Now a day, the availability of high-resolution probes and harmonic imaging are available which help to delineate location, homogeneity or heterogeneity, shape, and margins of salivary tumors. Ultrasonography can guide fine-needle aspiration up to the precision of 97% of the time in an outpatient setting, thereby reducing the need for any intraoperative biopsies or as guide for therapeutic procedures like guide to inject intra glandular botulinum toxin as treatment for dribbling (Braun, 1985).

Technique

- The examination should be carried out with the highest frequency transducer possible. [12] Usually, 5 to 12 MHz wide band linear transducers (medium frequency:7-7.5MHz or more) are used.
- In assessment of large tumors and lesions located in deep portions of the gland, 5 to10 MHz transducer may be useful. [13]
- Entire salivary glands and all lesions have to be evaluated in at least two perpendicular planes during ultrasonography examination.
- The whole neck should also be scanned to assess lymph nodes and search for concomitant or related diseases.
- High resolution ultrasound is a simple, readily available, non- invasive and reliable imaging tool for the evaluation of the salivary gland diseases. It gives definite information about location, size and extent of lesion.

Computed tomography (ct) and magnetic resonance imaging(mri) of salivary glands: CT and MRI are some of the advanced and finer imaging techniques used to evaluating the salivary gland pathologies, adjacent normal structures, and the proximity of salivary lesions to some of the vital structures like facial nerve, retromandibular vein, carotid artery, lymph nodes etc. CT-guided needle biopsy is useful to evaluate certain anatomically deep are as like the parapharyangeal space. Gadolinium-enhanced dynamic MRI can be used to differentiate a benign tumor like pleomorphic adenoma from some malignant tumors by using peak time of enhancement.
Recently, new MR technologies such as dynamic contrast-enhanced MRI (DCE-MRI), diffusion-weighted MRI (DW-MRI) and proton MR spectroscopy (MRS), and gadolinium-enhanced dynamic MR (Gd-MRI) imaging have proven to be very useful in differentiating benign from malignant tumors (Yabuuchi, 2003 and Yerli, 2010). Proton MR Spectroscopy has also been described for differentiation of benign from malignant tumors by some authors. Choline/creatinine ratios are significantly lower in malignant than in benign salivary gland tumors (King, 2009).

Positron Emission Tomography (PET): Positron emission tomography CT (PET/CT) provides a relatively noninvasive method of imaging that can be used to study pathological and physiological processes in the body, with the added advantage of anatomical localization. CT data is also obtained during scanning and the PET data is combined with CT that helps localize these radiotracers. e main application of PET/CT is in the assessment of patients with cancer using the glucose analogue 2- [18] fluoro - 2-deoxy- D-glucose (FDG) since the cancer cells have increased glucose utilization. FDG PET/CT plays a very vital role in the management of head and neck cancer (Wong, 2009).

Radionuclide Salivary Imaging (Nuclear Sialography): Scintigraphy with technetium (Tc) 99m pertechnetate is a minimally invasive diagnostic imaging technique used to assess the salivary gland function and to determine abnormalities in glandular uptake and excretion (Zapanta, 2009). Scintigraphy is possibly the only salivary imaging technique providing information on the functional capabilities of the glands. Following intravenous injection of technetium (which is a pure gamma ray–emitting radionuclide), it is taken up by the salivary glands, transported and secreted into the oral cavity. Uptake and secretion phases can then be recognized on the scans. e uptake of Tc 99m by a salivary gland indicates any functional epithelial tissue presence. The Tc-99m scan being able to correlate well with salivary output can be used as a measure of secretory function. Scintigraphy is indicated for the evaluation of patients when sialography is contraindicated or cannot be performed, such as in cases of acute gland infection or iodine allergy, or in cases where the major duct cannot be cannulated successfully.

Time-Activity Curve

Flow Phase: The flow phase lasts for approximately 15 to 25 seconds. Graphically, this phase is depicted by a line with a positive slope, representing increased glandular accumulation with time at a submaximal rate.

Concentration Phase: The second phase of the nuclear sialograms, the concentration phase, represents the accumulation of technetium within the gland. Graphically, this phase is represented by a horizontal line depicting continued uptake with time at a maximal rate. This usually starts 45 to 60 seconds following administration, progressively increasing over the next 10 minutes.

Washout (Excretory) Phase: The third phase, is accomplished by having the patient either suck on a lemon drop or by applying lemon juice to the tongue. Graphically this phase is depicted by a line with a negative slope, representing decreasing activity in the gland. Normally, there should be a prompt decrease in the amount of activity within the salivary glands during the subsequent 3 to 5 minutes.

Indications for Radionuclide Imaging: The principle clinical indication for technetium radionuclide salivary studies are as follows (Baum, 1981; Greyson, 1982 and Hauesler, 1977).

1. Evaluation of patients in whom contrast sialography is contraindicated or cannot be performed
   a) Patients with known iodine sensitivity.
   b) Patients with acutely inflamed glands.
   c) Patients in whom the ductal orifice cannot be located or cannulated.

2. Assessment of salivary function
   a) Evaluation of patients with chronic recurrent Sialadenitis
   b) Evaluation of patients with xerostomia due to autoimmune processes, e.g.; Sjogren's syndrome, obstruction, sialosis.

Sialoendoscopy: Sialoendoscopy is an innovative method for the management of salivary duct diseases (Al Washahi, 2014).
Plain film radiography is a fundamental part of the examination of the salivary glands and may provide sufficient information to preclude the use of more sophisticated and expensive imaging techniques. However, this technique is limited by the fact that 20% of sialoliths of the submandibular gland and 40% of those of the parotid gland are not well calcified, rendering them radiolucent and not visible in plain films (Al Washahi, 2014). Sialoendoscopy allows for optical exploration of the salivary ductal system and visualizing the pathology directly. Often final diagnosis can be made even in cases in which other imaging methods have not produced clear

results. It also helps in extraction of the stones, dilatation of stenosis and strictures under endoscope view (Escudier, 2005 and Geisthoff, 2009). Sialoendoscopy is now used as a routine diagnostic and therapeutic tool by many diagnostic and therapeutic centers, with the help of custom developed instruments (baskets, forceps, laser, drills). Fig 2.

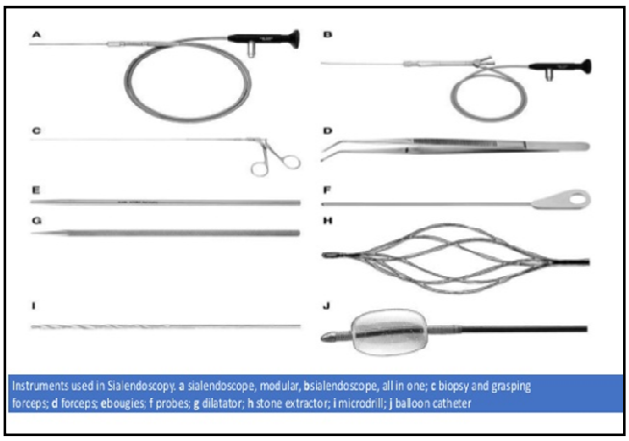

Fig. 2. Instruments used in sialoendoscopy

1] Diagnostic indication include salivary disease (Geisthoff, 2009; Nahlieli, 2001 and Turner, 2009)

- Sialolithiasis
- Mucus plugs
- Strictures and stenosis
- Salivary polyps
- Foreign bodies
- Extra ductal causes

-Muscle pressure, tumors, enlarged lymph nodes and denture flanges associated with the primary salivary ducts.

2] To diagnose undetected concrements, which may be left after sialoliths have been removed from the distal region of the excretory duct (Geisthoff, 2009).

Techniques

Sialoendoscopy begins with preoperative evaluation of the patient to ensure that the procedure can be performed with an expectation of success (Pedroletti, 2010)

General principle for sialoendoscopic procedure are as follows:

- Choice of the appropriate endoscope.
- Preparation of the optical system
- Orientation of endoscope
- Anesthesia for Sialoendoscopy
- Operative time
- Introducing the endoscope
- Irrigation
- Surpassing kinks
- Surpassing stenosis and strictures.

Diagnostic Sialoendoscopes

- Diagnostic Sialoendoscopy is a procedure in which main principle is to arrive at the pathology by following the duct system. The position of the tip of the endoscope can be determined by palpation, centimeter calibrations, or from the outside by the trans illumination effect.

Therapeutic Sialoendoscopes: Together with stenosis and strictures, stones are the main cause of obstructive salivary disease. Forceps, baskets, graspers, and balloons can be used to remove stones with an endoscopic control. Sialoendoscopy is performed as a treatment option both for chronic Sialadenitis and recurrent juvenile Sialadenitis. By irrigation saline duct systems are dilated and cleaned. Additional use of corticosteroids, the use of balloons, and perioperative antibiotics might be helpful (Bagewadi, 2013).

Conclusion

Imaging of salivary gland is a major challenge for radiologist's due to the great variety of pathologic condition that affect the salivary glands. It is important from the imaging point of view to detect, delineate the extent, involvement of adjacent structures and differentiate between benign and malignant lesions. Ultrasound should be the first line modality and should be combined with needle biopsy wherever possible. CT is useful, besides determining the attenuation of the lesion, in detection of calculi and bony involvement, however its use is limited by the high dose of radiation involved. MR, due to its excellent soft tissue contrast, is the preferred modality differentiating benign from malignant lesions. The limitations of MRI are limited availability and affordability. The awareness and understanding of various imaging techniques, as applicable in the field of salivary gland pathologies, shall be an important aspect of a medical professional in order to reach to a clear understanding of the pathology, making a definitive diagnosis and drawing a precise road map towards a successful treatment and a better prognosis.

Conflicts of Interest: None.

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