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Salivary gland imaging

A Project Submitted to

The College of Dentistry, University of Mosul, Department of Oral Diagnosis in Partial Fulfillment for the Bachelor of Dental Surgery

By

Anmar Eyad Tareq

Supervised by:

Lect.Dr. Shahrazad Sami Saeed

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Certification of the Supervisor

I certify that this project entitled "Salivary gland imaging" was prepared by the fifth-year student Anmar Eyad Tareq under my supervision at the College of Dentistry/University of Mosul in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

Signature:

Lect.Dr. Shahrazad Sami Saeed

Date: / / 2025

Dedication

This study is wholeheartedly dedicated to my beloved parents, who have been my source of inspiration and gave me strength when I thought of giving up, who continually provide their moral, spiritual, emotional, and financial support.

To my brothers, sisters and friends who shared their words of advice and encouragement to finish this study.

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I thank God first and foremost for his countless love and support always; I pray that I will live up to be a responsible Dentist.

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Dr. Rayan Salim.

The completion of this project could not have been possible without the participation and assistance of so many people whose names may not all be enumerated. Their contributions are sincerely appreciated and gratefully acknowledged.

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List of Abbreviation

Symbol	Abbreviation
CBCT	Cone-beam computed tomography
MRI	Magnetic resonance imaging
US	Ultra sound

Introduction

Major and minor salivary glands produce and secrete digestive fluids or protein-rich fluids. The three pairs of major salivary glands are responsible for the production and secretion of saliva in the oral cavity, whose moisturizing effect preserves oral hygiene and allows taste, speech and mastication (Amano *et al*, 2012).

The **major salivary glands** play a crucial role in oral health and functionality. Their secretions help maintain oral hygiene, aid in mastication, and facilitate taste and speech (Amano *et al*, 2012). Each of the three major glands has distinct characteristics:

- The **parotid gland:** primarily consists of serous acini that secrete α-amylase-rich saliva, aiding in carbohydrate digestion (Dobrosielski-Vergona *et al*., 1993).
- The **sublingual gland:** produces a mucous secretion rich in mucins, forming a thick and viscous fluid (Korsrud *et al*., 1980).
- The **submandibular gland: contains** a mixed population of acini, combining both mucous and serous functions (Smith *et al*., 1987).

Together, these three glands account for over **90% of total salivary secretion**. The **minor salivary glands**, distributed throughout the oral cavity—including the labial and lingual mucosa, palate, and floor of the mouth—also contribute to saliva production. (Kondo & Nakamoto, 2015).

Saliva is an essential fluid for maintaining oral cavity health and functionality (Treuting *et al*., 2012). It contains **digestive enzymes** that initiate food breakdown while simultaneously lubricating solid nutrition, easing its passage through the esophagus (Kondo & Nakamoto, 2015).

Saliva plays a vital role in maintaining oral health and functionality. By moisturizing the tongue and other oral tissues, it enhances speech and taste sensitivity, additionally; saliva helps maintain pH balance in the mouth, protecting soft tissues and teeth from prolonged exposure to acidity. (Matsuo *et al*, 2000).

Moreover, saliva possesses antibacterial and antifungal properties, helping to prevent infections and dental caries. Components such as lysozymes, immunoglobulins, and lactoferrin work together to inhibit bacterial growth and maintain oral hygiene. (Porcheri, 2019)

Salivary gland abnormalities such as, sialolithiasis, Sjogren's syndrome, and ductal strictures are commonly seen in adults and prior to endoscopic or surgical treatment, precise radiological evaluation and mapping of salivary gland ducts is necessary for better outcome and prognosis (Rastogi R *et al*, 2012)

Depending on the pathology, certain radiographic imaging methods are used, often complementary. These are: conventional radiography, ultrasound (US), CBCT (Cone Beam Computed Tomography) and MRI (Magnetic Resonance Imaging). (Hébert G, 1993)

Aim of study

The aim of this study is to able the dentist to discover different methods in imaging of salivary glands for better diagnosis the diseases that affect major and minor salivary gland in oral and maxillofacial region, and show the importance of different imaging modalities in diagnosis of salivary glands' diseases.

Chapter one

Review of Literature

1.1. Types of major salivary gland

1.1.1 Parotid Gland

The parotid glands are the largest of the major salivary glands, located on either side of the face, wrapped around the mandibular ramus and positioned posterior to the mandibular ramus and anterior to the mastoid process of the temporal bone (Bialek *et al*., 2006). These glands play a crucial role in mastication and swallowing by secreting saliva and amylase, an enzyme responsible for the digestion of starches (Nanci, 2018).

Structurally, the parotid gland is a serous-type gland, meaning it primarily secretes alpha-amylase (ptyalin) (Holmberg & Hoffman, 2014). Saliva from the parotid gland enters the oral cavity via Stensen's duct. These glands contribute approximately 20% of the total salivary secretion in the mouth.

From a clinical perspective, the parotid gland is significant in facial nerve anatomy, as dissections exposing its different lobes must be performed carefully to avoid iatrogenic injury to the facial nerve branches, which could result in loss of muscle function or strength in facial expression (Holmberg & Hoffman, 2014).

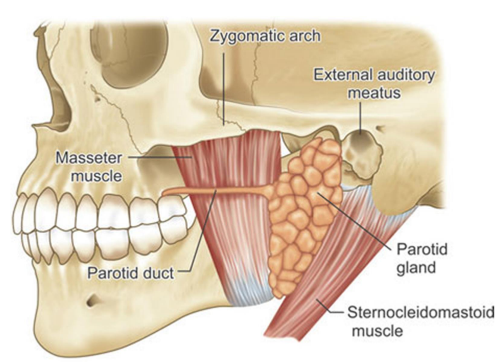

Fig.1.1 parotid gland

1.1.2 Submandibular glands

The submandibular glands are a pair of major salivary glands located beneath the lower jaws, just superior to the digastric muscles (Bialek *et al*., 2006). These glands produce a mixed secretion of both serous fluid and mucus, which enters the oral cavity through the submandibular duct (Wharton duct).

Although the submandibular glands are smaller than the parotid glands, they are responsible for producing around 70% of the saliva in the oral cavity (Nanci, 2018).

Clinically, the submandibular glands can often be felt through palpation of the neck, as they are located in the superficial cervical region and typically feel like a rounded ball. They are positioned about two fingers above the Adam's apple (laryngeal prominence) and approximately two inches apart under the chin. (Nanci, 2018).

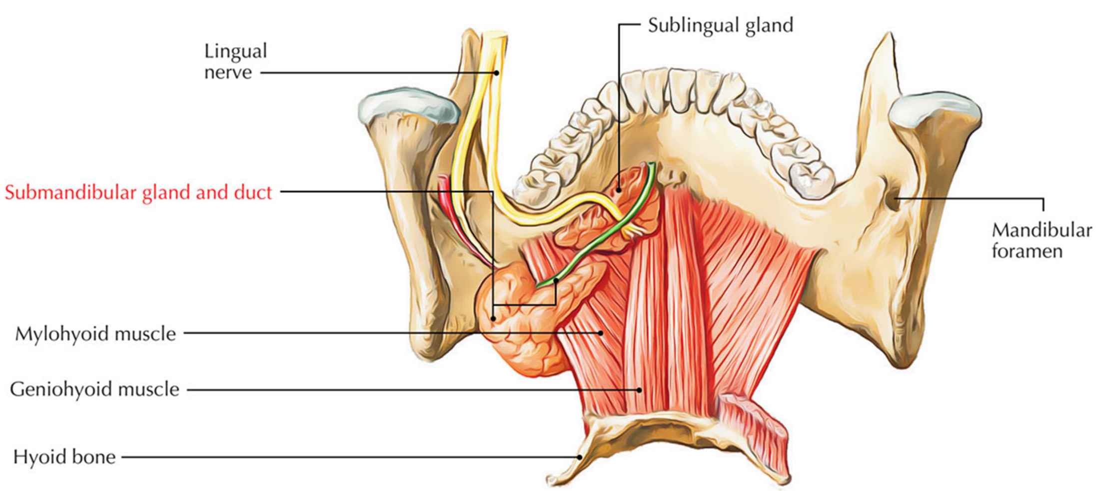

Fig 1.2 submandibular gland & duct

1.1.3 Sublingual glands

The sublingual glands are a pair of major salivary glands located inferior to the tongue and anterior to the submandibular glands. These glands primarily produce mucous secretion, although they are classified as mixed glands. (Bialek *et al*., 2006)

Unlike the other two major salivary glands, the ductal system of the sublingual glands lacks intercalated ducts and typically does not have striated ducts. Instead, saliva is secreted directly through 8-20 excretory ducts, known as the Rivinus ducts.

The sublingual glands contribute approximately 5% of the total saliva entering the oral cavity (Nanci, 2018).

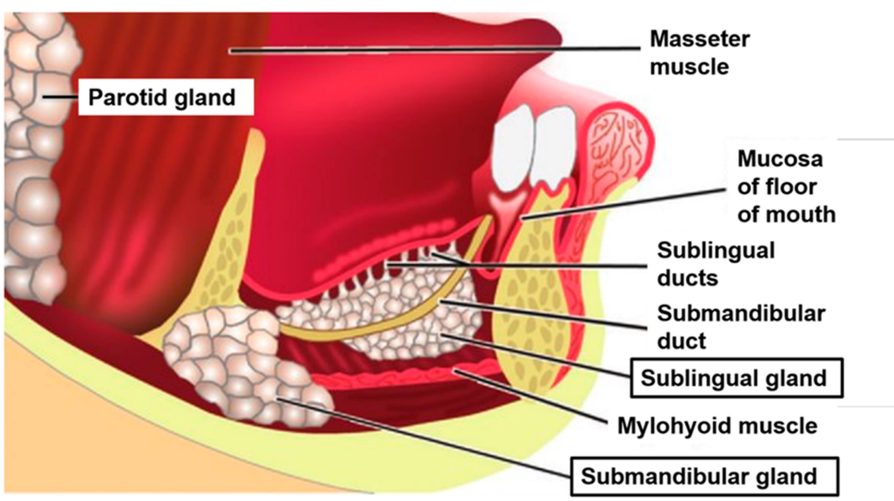

Fig 1.3 sublingual gland & dusts

1.2. Types of salivary gland imaging:

1.2.1Conventional sialography

For conventional sialography, patients with clinical evidence of salivary gland non-tumour pathology or presence of parotid or submandibular gland masses are made to undergo baseline or scout lateral oblique and anteroposterior radiographs of the involved major salivary gland to assess the presence of radiopaque calculi before injection of the contrast agent. (Kandula *et al,* 2023).

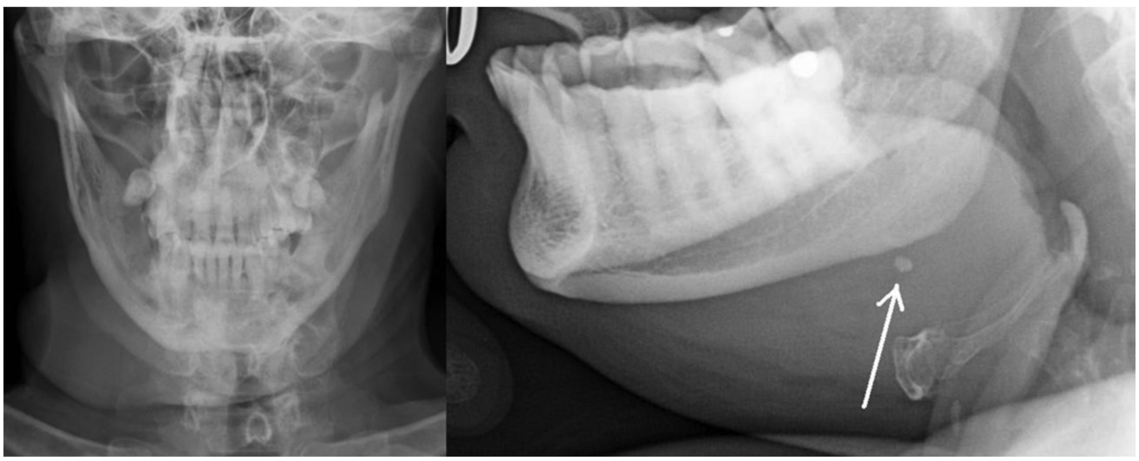

Fig.1.4 small calculus (arrow) visible on lateral oblique view taken with depressed tongue

The oral opening of the salivary gland duct is dilated using a probe, followed by cannulation with an intravenous catheter or cannula. If the ductal orifice is difficult to locate, salivary stimulation can be facilitated by applying citric acid crystals on the tongue to aid in catheter insertion. (Kandula *et al*, 2023).

Once the catheter or cannula is securely positioned, up to 2.5 mL of water-soluble iodinated contrast agent is injected into the duct through a small polyethylene tube until the patient experiences a sensation of fullness or discomfort. Typically, 2–2.5 mL of contrast is administered for the parotid gland, while 1–1.5 mL is used for the submandibular gland. Following contrast instillation, lateral and oblique radiographs are taken. Upon completion of the procedure, the patient is instructed to suck on lemon juice to facilitate contrast evacuation, and a post-procedure radiograph is performed approximately five minutes later to confirm clearance. (Kandula *et al*, 2023).

1.2.2 Cone-beam computed tomography (CBCT)

CBCT imaging is useful for assessing structures within and around the salivary glands; however, it has limitations in differentiating soft tissue densities. It effectively detects minimally calcified sialolithiasis and serves as a useful recording modality for conventional sialography, offering three-dimensional visualization of the ductal system. (White and Pharoah, 2014)

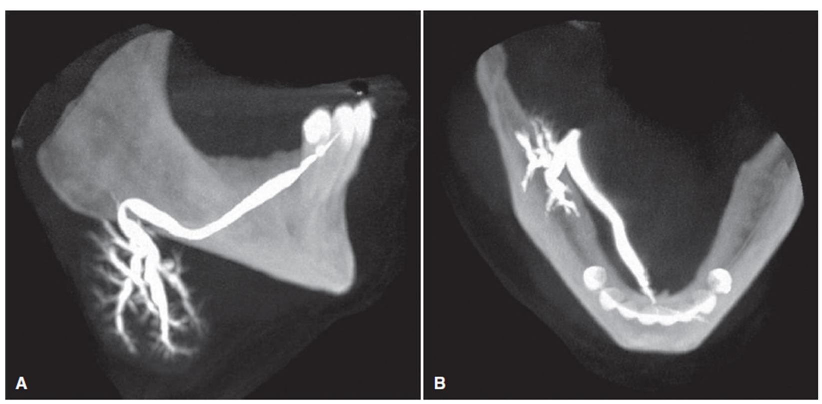

Fig.1.5 Conventional sialography of a submandibular gland imaged with CBCT imaging. The images are rendered in lateral **(A)** and axial **(B)** views.

1.2.3 Magnetic resonance imaging (MRI)

MRI is a highly effective modality for evaluating salivary gland pathologies due to its superior soft tissue contrast resolution and ability to minimize artifacts from metallic dental restorations, (Abdel Razek & Mukherji, 2018).

MRI provides detailed visualization of salivary gland structures, including parenchymal tissues, ducts, and adjacent soft tissues, making it particularly useful for diagnosing masses, cysts, and inflammatory conditions, MRI does not use ionizing radiation, which is advantageous for repeated imaging and for use in sensitive populations (Madani & Beale, 2016).

The absence of streak artifacts from dental materials further enhances image quality, allowing for more accurate diagnosis of salivary gland disorders.

MRI is often used as an alternative to conventional sialography, especially when ductal catheterization is challenging or contraindicated, such as in cases of acute infection or iodine sensitivity (Patel & van Zante, 2019).

MRI is the preferred modality for assessing the extent of lesions and their invasion into adjacent tissues or spaces, which is crucial for surgical planning and treatment (Shah, 2021).

1.2.4 Ultra sound (US)

Compared to MRI, US offers several advantages, including affordability, widespread availability, painless application, ease of use, absence of ionizing radiation, and non-invasiveness. One of the primary uses of US in salivary gland imaging is distinguishing solid masses from cystic ones and guiding fine-needle aspiration biopsies. Recent studies also indicate that US can be beneficial in detecting sialoliths and diagnosing advanced autoimmune conditions such as Sjögren's syndrome. However, a notable limitation of US is its inability to accurately assess the extent of tumors located in the deep lobe of the parotid gland. (White and Pharoah, 2014)

1.3 Types of Contrast medium

Water-soluble contrast agents are preferred over oil-based iodinated agents like lipiodol due to their lower viscosity, reduced surface tension, better miscibility with salivary secretions, and rapid excretion post-procedure. Additionally, they require less injection pressure for glandular filling, minimizing patient discomfort and pain (Kandula *et al*, 2023).

Water soluble iodinated contrast agents are available as:

(i) Ionic monomers or dimers referred to as high osmolar contrast media, for example diatrizoate (hydropaque, urografn, and renografn), iothalamate (conray).

(ii) Non-ionic monomers or dimers referred to as low osmolar contrast media for example, iohexol (omnipaque), iopamidol (ultravist), iopromide (isovue, iopamiro, iopamiron, niopam).

Water soluble, non-ionic, iodinated contrast agents do not dissociate into charged particles, tend to have low osmolality, and are less toxic with low incidence of adverse reactions on injection than ionic contrast agents (Rzymska-Grala I , 2010)

Few clinicians prefer to use oil-based iodinated contrast agents as they remain in the salivary gland ducts for longer duration thereby producing satisfactory degree of opacifcation, but extravasation of oil-based contrast agent may lead to severe foreign body reactions and necrosis or fbrosis of salivary gland parenchyma (Kandula *et al* ,2023).

1.4 Normal sialogram

Normal sialogram of a major salivary gland presents as a “leafless tree”, “tree in winter” or “bush in winter” appearance. The primary duct is uniformly fine without any presence of terminal dilatation. Submandibular ducts are much shorter and wider than parotid duct thereby increasing (Kandula *et al* , 2023).

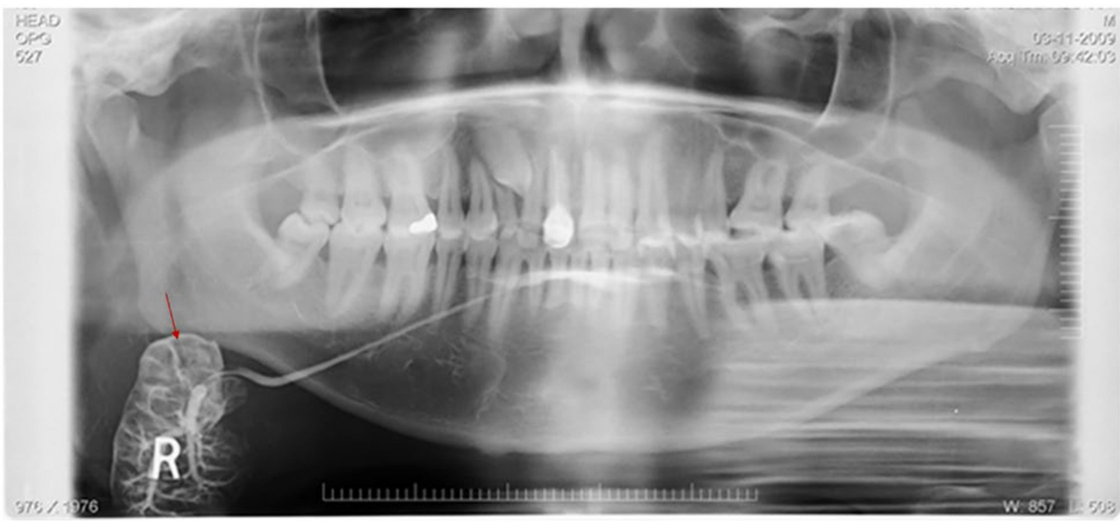

Fig. 1.6 Panoramic sialogram reveals normal right submandibular gland giving “Bush in winter”.

1.5 Sialendoscopy

Since its first use in the 1990s, sialendoscopy, which involves direct visualization of the parotid and submandibular major ducts, has transformed the diagnosis and management of obstructive conditions in these glands. This minimally invasive technique is equipped with sialolith retrieval and stricture dilation tools, enabling the management of common obstructive conditions with reported success rates greater than 95%. (White and Pharoah, 2019)

Sialendoscopy provides both diagnostic and therapeutic benefits by offering better visualization of the ductal system and facilitating the treatment of obstructive sialadenitis with considerably less morbidity. Additionally, a significant percentage of affected glands show a normal histologic appearance and regain function after the removal of stones. (Carta *et al*, 2017)

One of the main advantages of sialendoscopy is that it allows for gland preservation while effectively relieving obstruction. It is a day-care procedure with minimal morbidity and can be performed in patients of all age groups, making it especially beneficial for elderly patients with co-morbidities. (Carta *et al*, 2017)

Traditional surgical excision (sialectomy) carries the risk of nerve injuries, primarily involving the marginal mandibular nerve, lingual nerve, hypoglossal nerve, and facial nerve. The classic external approach also has potential complications such as bleeding, infection, and scarring. (Carta *et al*, 2017)

The introduction of flexible endoscopes, thin enough to be introduced into the salivary pathway, was first proposed by Katz. The subsequent development of micro-instruments has allowed for conservative, minimally invasive treatment of salivary gland diseases. These advancements enable procedures such as ductal dilation of stenotic ducts, and stone retrieval using forceps or baskets, significantly reducing the need for gland excision. (Carta *et al*, 2017)

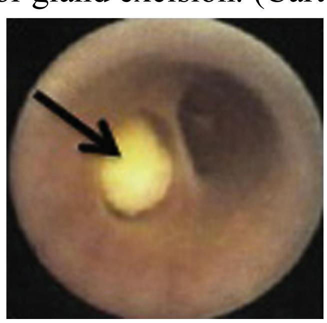

Fig 1.7 Sialendoscopy allows direct visualization of the salivary gland

1.6 Some Common Salivary Gland Diseases

1.6.1 Sialolithiasis

Sialolithiasis is the most common salivary gland disorder found in patients between 30 and 60 years of age and is characterized by formation of salivary calculi or sialolith inside the salivary gland duct (Jardim EC *et al*, 2011)

80 to 90% cases of sialolith in the submandibular gland which may be due to more viscous, mucous, and alkaline secretions from the submandibular gland duct or Whartons duct (Abdullah O et al, 2016)

The patient reports with the complain of pain and recurrent swelling in the parotid or submandibular region which becomes more pronounced during eating because of impaired salivary flow due to obstruction in the salivary gland duct. In chronic cases, gland undergoes atrophy and patient reports no symptoms unless there is secondary infection proximal to the ductal obstruction resulting in bacterial sialadenitis, Radiographically, sialoliths may appear as radiolucent or radiopaque depending upon the degree of calcification (Jardim EC *et al*, 2011)

Sialography is useful in detection of sialoliths which are undetectable by plain radiographs or if they are radiolucent. CT images, sialoliths appears as single or multiple small hyperdense structures with variable shape i.e. long cigar, oblong, round or oval. The radiopaque contrast agent usually flows around the sialolith and fills the duct proximal to the obstruction. It has been documented that 80% parotid and 20% submandibular gland sialoliths are poorly calcified, “ mucous plugs” which appear as partial or complete filling defect/void, and CT sialography is a modality of choice in such case scenarios (Abdullah O et al, 2016)

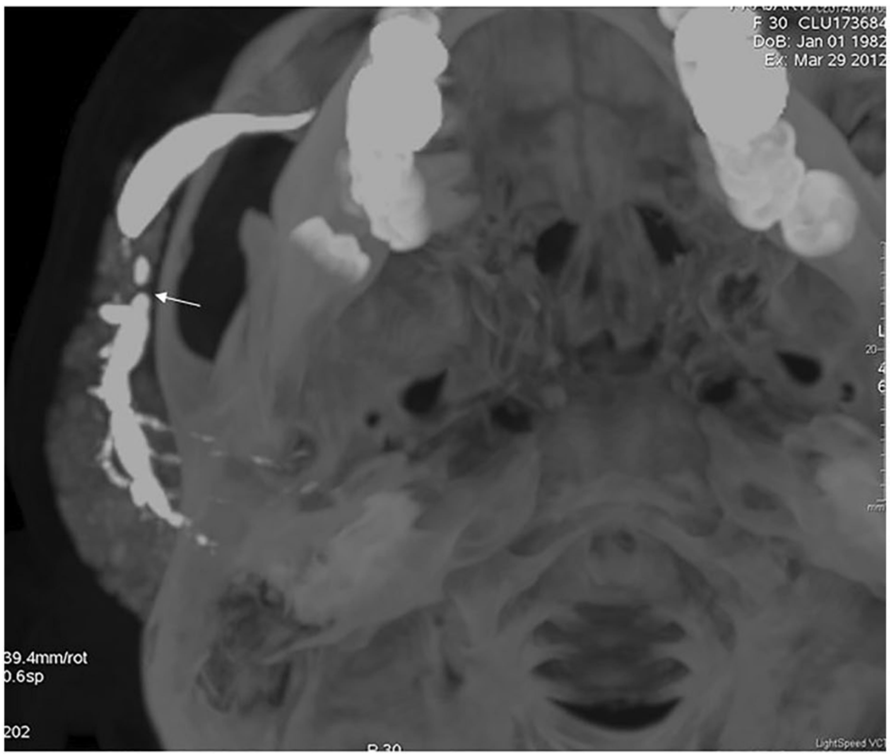

Fig.1.8 CT sialogram reveals stricture in right parotid duct which appears as filling defect and dilatation of duct distal to stricture

1.6.2 Sjogren's syndrome

Sjogren's syndrome also termed as autoimmune sialadenitis is a chronic autoimmune disorder characterized by lymphocytic infiltration of exocrine glands predominantly salivary and lacrimal glands, resulting in symptoms of dry mouth (xerostomia) and dry eyes (keratoconjunctivitis sicca). Sjogren's syndrome has been reported to commonly involve the parotid glands with 90 to 95% female prevalence aged between 40 and 60 years. (Singh AG *et al*, 2016)

Genetic, environmental, immune system dysfunction and hormonal alterations have been reported to be associated with occurrence of this condition and patient often reports with the complain of mucosal dryness and sometimes recurrent parotid gland enlargement. (Singh AG *et al*, 2016)

The weakening of the epithelial lining in the intercalated ducts leads to extravasation of the contrast agent, causing its leakage outside the ducts and contributing to the distinctive imaging findings. These results in characteristic sialographic patterns described as "cherry blossom," "apple tree in blossom," or a "branchless, fruit-laden tree," representing multiple globular or cavitary collections of contrast medium, indicative of glandular damage in Sjögren's syndrome. (Kandula *et al*, 2023).

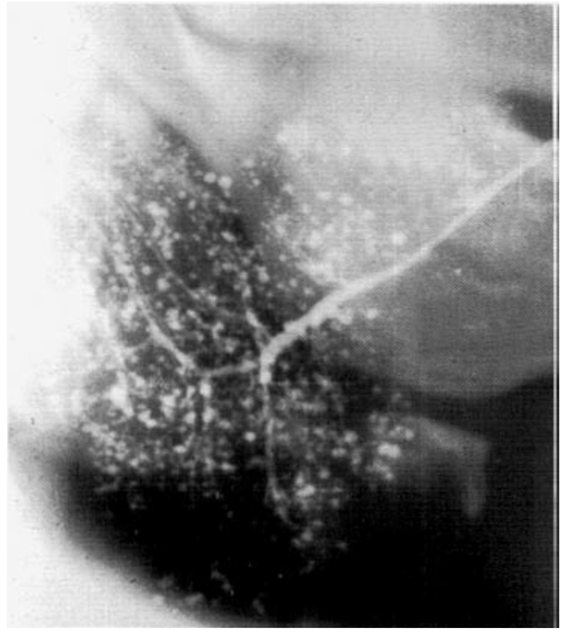
Fig. 1.9 Sialograph of a right parotid gland of a patient with Sjogren's syndrome.

Chapter Two

Conclusion

- Salivary gland imaging plays a crucial role in diagnosing and managing various disorders affecting the salivary glands.
- Techniques such as US, CT scans, MRI, and sialography provide valuable insights into the structure and function of these glands, aiding in the detection of conditions like infections, tumors, stones, and inflammatory diseases.
- sialendoscopy is a minimally invasive procedure that offers effective treatment for salivary gland disorders, preserving gland function while alleviating obstructions.
- Imaging helps assess gland size, ductal patency, and the presence of pathologies, contributing to more accurate treatment planning and improving patient outcomes.

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