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Sialoendoscopy: Review and Nuances of Technique

Srinivasa Rama Chandra[1]

Abstract

Introduction Sialoendoscopy is a nuanced technique of transluminal management of obstructive and nonneoplastic pathology of the major salivary glands. Techniques have been refined in the last two decades due to advances in optical and endoscopic instrumentation. This minimally invasive technique has both diagnostic and therapeutic applications. Obstructive salivary gland disease due to mineralized stones causes the majority of salivary duct-related pathology. Mucus plugs and strictures are the other causes. Submandibular gland sialolithiasis comprises the majority of salivary ductal pathology, with less than ten percent of obstructive symptoms related to parotid gland.
Objective The aim of this review is to comprehensively understand the scope of practice, the methodology of management, and the techniques for a successful outcome in sialoendoscopy. Anatomy of the salivary glands and the ductal system is reviewed for a successful outcome. Guidance for patient selection, indications, investigations, and preprocedure preparation for sialoendoscopy are discussed. Algorithms and an instrument checklist are provided in table format in the manuscript for clinical utility.
Conclusion The author simplifies the various systems of sialoendoscopes and the utility of the instruments. The future of transluminal and intraluminal salivary procedures is within the oral and maxillofacial surgical realm with simulators and multidimensional imaging and navigational advances.

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Introduction

Escudier and McGurk [1] state on basis of hospital admissions due to salivary obstructive symptoms the incidence is between 1 per 15,000 and 1 per 30,000. Traditional management of obstructive luminal symptoms was either symptomatic medical management or radical surgical removal of the major salivary gland. The advanced understanding of the glandular ductal pattern of the major salivary glands, pathology and associated adjacent anatomical structures has allowed sialoendoscopy, a minimally invasive technique, to become a good adjunctive alternative.

Oral and maxillofacial surgeons have been involved for many years in the setting of sialography and imaging for diagnostic and therapeutic indications. Smaller scopes in the temporomandibular joint interventions are common in maxillofacial surgical management. Extending this expertise and the success of urologic endoluminal procedures with the advancements in optical technologies have extended minimally invasive sialolithiasis management. The percentage quoted for stone extrication is approximately 75% Marchal et al. [2] and the learning curve for this technique is estimated to be 30 procedures [3]. Experience with airway or gastrointestinal endoscopic procedures is not known to translate to sialoendoscopic procedures due to the finer and nimble instruments and technique.

History

Sialography historically was seen as therapeutic intervention as well, in many diagnostic and obstructive symptoms of major salivary glands. Water-soluble radiopaque dyes were injected retrograde with ductal cannulation and serial radiographic images obtained. Radioiodine when administered, twenty-four percent is lost through the saliva, and concentrations of ^{131}I in saliva range from 20—100 times the levels comparatively found in plasma. Despite several decades of use, sialography and its complications has offered poor insight into the anatomical aspects of major salivary gland sialoendoscopy [4].

Indications

Obstructive Salivary Gland Diseases

1. Sialolithiasis, sialoadenosis.
2. Stenosis.
3. Mucous plugs.
4. Scarring and adhesions.
5. Foreign bodies and polyps.

Secondary Salivary Stasis

Autoimmune disorders of saliva glands.
Immunoglobulin G 4 related to sclerosis.
Sjogren's syndrome.
Juvenile recurrent parotitis.
Masseter muscle hypertrophy-related obstructive parotitis.
Radioiodine sialoadenitis.

Sialolithiasis

Sialoliths between 4 and 5 mm diameter are amenable to sialoendoscopy. Obstructive salivary gland disease due to mineralized stones causes the majority of salivary ductal-related pathology. Submandibular gland sialolithiasis contributes the majority of sialoliths and less than 10% obstructive symptoms are related to parotid gland. The stone size is determined by the long axis, and majority of stones take the shape of the length of the duct.

Autoimmune Disease and Sialoendoscopy

Sjogren's syndrome involves all exocrine glands; it is of autoimmune nature with glandular infiltration of CD4+ T lymphocytes. This intermittent, painful, symptomatic bilateral glandular disease affects the ductal system by lymphocytic infiltration. Ductal hyperemia is noted on endoscopy with luminal congestion and obstruction. Advanced disease condition with autoantibody infiltration of the parenchyma with destruction and neuronal degeneration is observed intraluminally as pale ductal sclerosis and obstructions with mucus plugs and stenosis.

Mikulicz syndrome, Kuttner tumor, chronic sclerosing sialadenitis, and juvenile recurrent parotitis are conditions of autoimmune pathogenesis with a role for sialoendoscopy. Diagnostic applications for sialectasis, therapy by corticosteroid irrigations, and mucus plug relief by irrigations are utilized.

Radioiodine Associated Sialoadenitis

Salivary glands have a sodium–iodine (Na/I) symporter in the ductal and parenchymal cells which accumulate I131 after radioactive ablation treatment of differentiated thyroid carcinoma. It has been reported that approximately 24% of administered radioactive iodine I-131 is secreted in saliva and is concentrated in the salivary gland at 20–100 times the plasma level. Radiation causes destruction leading to obstructive sialadenitis and increased vascular permeability leads to loss of plasma protein and electrolytes. The serous parotid glands are more affected than the mucus glands. Ductal obstruction, duct infiltration, retrograde infection, and biochemical alteration due to parenchymal destruction causes chronic changes of the salivary gland. This bilateral disease typically presents fairly early after the radioactive iodine treatment but can also develop up to a year posttherapy. Sialoendoscopy has a therapeutic role and is used in conjunction with systemic and local therapies of massage, steroids, heat, etc. This has been well documented by various studies by Shacham et al. [5], Nahlieli and Nazarian [6].

Anatomical Considerations

Anatomical knowledge aids successful outcomes, including variations to ductal patterns and luminal alterations by disease. There are two main ducts and branching first-order ducts. The epithelia lining the duct is fairly transparent revealing small capillaries. This contributes to the pinkness unless there are strictures, stenosis, and scarring. Circular ridges are visualized due to muscular or periductal tissues especially around the papilla. Hilum at the opposite end of the duct length reveals bi- or trifurcating ductal patterns. Posthilar areas or intraparenchymal regions can be carefully visualized.

Submandibular and Sublingual Gland

Nahlieli and Nazarian [6] describe in detail anatomy of submandibular and sublingual glands with the three types

of major ductal relationships. The submandibular duct as described by Thomas Wharton is approximately 4–6 cm long with an average diameter of 1.5 mm. Orifice diameter ranges between 0.5 and 0.1 mm with its opening just lateral to the lingual frenum on the floor of the mouth on the surface of the sublingual caruncle. The sublingual gland contributes multiple accessory ducts to the principle lumen of the Wharton duct. Once on the surface of the mylohyoid muscle it is crossed by the lingual nerve from a lateral to medial direction. The duct is also superior to the hypoglossal nerve posteriorly. The duct is lateral to the hyoglossus and genioglossus muscle up to the edge of the mylohyoid posterior border. The duct forms an angled turn at this intraglandular location to the undersurface of the mylohyoid. This is called the "genu" and the angle varies between 24° and 178°. Stones distal to this point are difficult to manipulate.

duct is at the anterior superior edge, a finger-breadth below the zygomatic arch. It passes through the buccal fat pad, buccopharyngeal fascia and buccinator muscle opening laterally to the second maxillary molar in the oral mucosa. It can be palpated by having the patient clench and rolling the duct on the surface of the masseter. The duct is 4–7 cm long, with an average diameter of 1.4 cm. The orifice is 0.5 mm and 1.2 mm at the transbuccinator muscular sphincteric passage.

Algorithms in Decision Making [7]

Algorithms in decision making depend on patient, gland, stone size, form and mobility, prior procedures and location inside the duct system and the dexterity and experience of the operator.
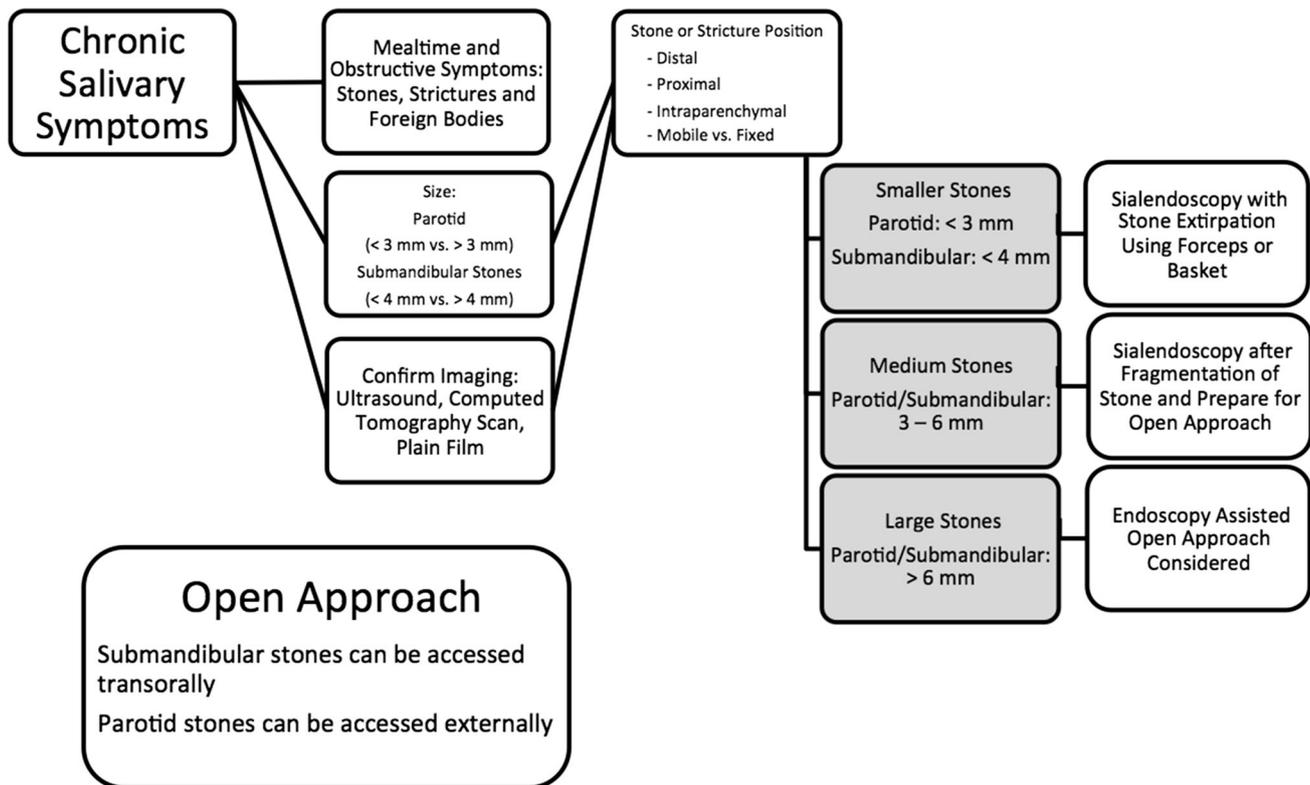
Parotid Gland Anatomical Considerations

Parotid duct architecture can be determined from the cutaneous surface as a perpendicular line from the tragus to a line between the inferior lateral point of the alar cartilage and angle of the mouth. Secondary and the tertiary ducts arising from the medial and the lateral lobe of the parotid form the Stensen's duct. The convergence into the terminal

Smaller stones can be extirpated during endoscopy (< 4 mm in the submandibular gland, < 3 mm in the parotid gland).

Intermediate-size stones (5–7 mm) need fragmentation–holmium laser or lithotripsy prior to endoscopic extraction.

Large stones (> 8 mm) would need combined open or multiple attempts for extirpation of stones.

Preprocedural Preparation

Discussion regarding anesthesia is mandatory. Brief interventions can be under local anesthesia, topical medications can be used for ductal dilatation; however, sedation and general anesthesia are also utilized. Advantages of general anesthesia are adequate patient compliance and utility for longer procedures or combined approaches of the intra- and extra-oral techniques including gland resection. Patient has to be prepared with instruction for increased self-hydration, gentle salivary gland massage, warm compresses, sialagogues, oral steroids, and analgesics. Perioperatively, aggressive hydration, intravenous antibiotics, and cholinergic agonist medications are administered.

Diagnostic procedures can be as short as several minutes with interventional procedures lasting as long as an hour. Transcutaneous incision on a palpable large parotid stone can be made and extirpated under local anesthesia if it is larger than approximately 15 mm in diameter or intraparenchymal.

Investigations

Sialography Historical use, has some utility. Radiocontrast injection is contraindicated in patients with contrast allergy, acute inflammation, or with risk of extravasation. Air bubbles lead to false positive images. Incorporation of sialography along with endoscopy can identify very small stones in smaller excretory ducts.

Ultrasound of the salivary glands can distinctively differentiate between general neoplasia and inflammatory disease. Ultrasound is repeatable and noninvasive. Visualization of the salivary ductal system is not possible in routine circumstances. The glands appear hyperechoic in normal state. Enlargement, hypoechogenic, nonhomogeneous spongy architecture with duct visibility is seen in diseased state. Calcified ductal obstructions appear hyperechoic with distal acoustic shadowing. This scatter could be difficult in visualization. Mandible or hyoid bone can give aberrant dense acoustic shadowing. Stones less than 2.4 mm cannot be identified by ultrasonography.

Plain radiographs visualize stones if they are greater than 3 cm and very well calcified. The location of the sialolith can be obscured by overlying structures. Half of parotid stones cannot be diagnosed on plain radiographs and one-quarter of submandibular stones are obscured by the nonocclusal type plane film radiographs.

Magnetic resonance imaging (MRI) identifies the duct nonspecifically but does not visualize stone architecture well. Developments in magnetic sequencing can give 3D subtraction images of the ductal pattern.

Computed tomography scans (CT) are commonly used for glandular architecture, obstructive location, and visualization of the stones. But as with other imaging techniques, the limitation is of the lack of detail in the duct distal to the obstruction. CT scans can be used with contrast and with low-dose techniques (Figs. 1, 2).

(I)   Axial CT image with a right floor of the mouth Wharton duct sialolith.

(II) Coronal image of the right floor of the mouth sialolith of the same patient.

(III) Panoramic images reveal the stone in very subtle detail, but occasionally this can be missed in these panoramic exams.

Technique Major Stages

The main duct manipulation is categorized into three large stages.

1. Orifice and papilla identification and dilatation
2. Duct wall visualization and characterization
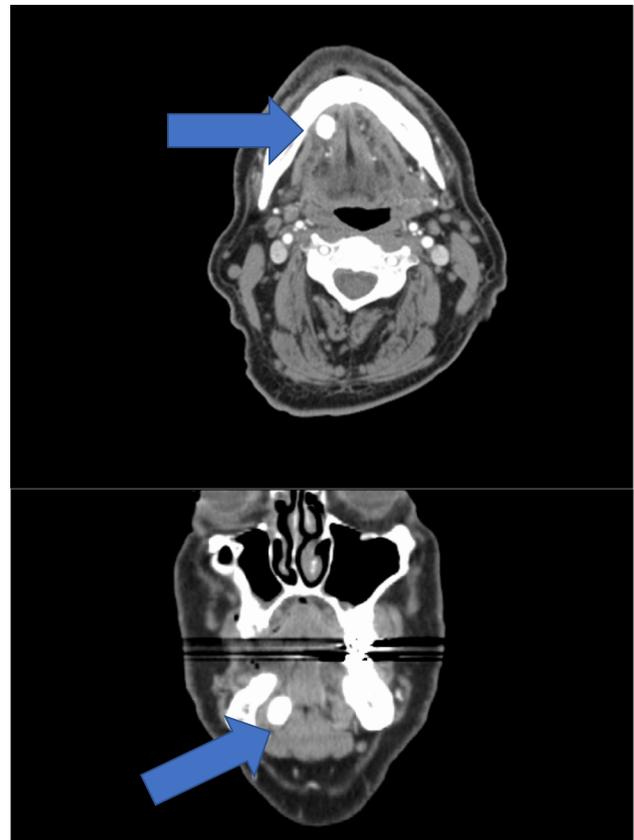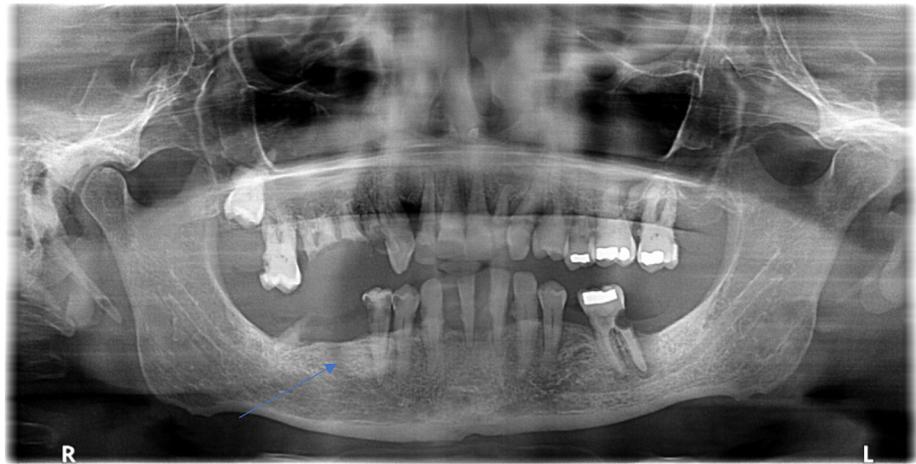3. Endoluminal stricture or stone manipulation

Fig. 1 CT scans in axial (above) and coronal (below) section of scan revealing a large sialolith in the right anterior floor of the mouth

Fig. 2 A panoramic radiograph shows a halo of the evidence of a calcified stone in the right floor of the mouth in comparison with the Fig. 1

Sialoendoscopy Equipment: A Check List

1. Diagnostic scopes (0.8 mm, 1.0 mm, 1.3 mm diameter).
2. Operative scopes (diameters).
3. All-in-one type of scope of multi-luminal scopes.
4. Cold lighting source.
5. Video camera.
6. Monitor—wheel-mounted or wall-mounted system.
7. Irrigation system—most simple is a 20-mL syringe filled with saline attached by intravenous catheter.
8. Wire basket—for extirpation of stones and foreign bodies.
9. Grasping forceps.
10. Balloons—intraluminal dilators.
11. Laser fibers—fragmentation and incisions.
12. Microdrills—fragmentation of sialoliths.

Endoscopes: The Fine Detail

The majority of sialoendoscopes have a lumen for diagnosis, hydrodissection and dilation and a separate working port. The working port is used for stone retrieval by basket deployment, laser fibers, and microdrills for fragmentation, microforceps for manipulation. Some endoscopes have a 0.2 mm lumen port for irrigation. Marchal scopes (flexible or semi-flexible) have an outer diameter between 0.89 and 2.29 mm with an optic fiber of at least 6000 pixels for image quality. Earlangen scopes have a range of 0.8–1.6 mm in diameter with a semi-flexible, three-channel endoscopy set. A wire basket for stone retrieval has an outer diameter of 0.4 mm with four wires which can be deployed in the lumens of the endoscope. Graspers and biopsy forceps have an outer diameter of 0.78 mm and are used for manipulation, extirpation, and biopsy. Injections

of anesthesia, steroids, corticosteroids, and contrast agents can be done through these ports too. Balloon dilation of intraluminal strictures with utilization of controlled pressure pumps, stent insertion for severely inflamed duct segments, as well as injured papilla can also be performed. The stents are usually deployed over the endoscopes as a sheathing technique and subsequently carried intraluminally. The stents are between 2 and 4 cm. Repeat prednisolone can be administered at a dose of 50 mg weekly for inflammatory conditions or stenosis prevention. Any irrigation should be accounted with outflow and never done with excess pressure.

Lithotripsy, Lasers and Combined Approaches

Stones more than 4 mm diameter and spiculated calcified stones are difficult to remove with sialoendoscopy alone. Other than mechanical microdrills extracorporeal shock-wave lithotripsy (ESWL) and intracorporeal lasers are utilized to fragment the mineralized sialoliths. Intracorporeal lithotripsy by shockwave is known to cause ductal damage. Based on the availability of the lasers and ESWL, there are different algorithms as noted by Gallo et al. [7] in the 2014 roundtable review reports (Fig. 3).

Extracorporeal/Transcutaneous/Lithotripsy

Lithotripsy fragmentation either transorally or transcutaneous with subsequent intraductal extirpation of sialoliths are done in centers with this capability [8]. Ultrasonography will focus energy to the stone. Electromagnetic and Piezoelectric methods cause cavitation by compressive and expansive waves at the calcification and water interface. Following this fragmentation physiological expulsion of the stones by salivary flow and endoscopic techniques with

Fig. 3 Picture of retrieved stones with sialoendoscopy and fragmentation. The measurement of the largest stone at 8 mm is represented

irrigation are therapeutic. The major indication for this procedure is parotid stones, and it is more effective with parotid stones in comparison with submandibular stones. Pregnancy, cardiac pacemaker, and total distal duct stenosis are contraindications to ESWL. Relative contraindications are inflammatory painful glandular swellings. Postprocedural tenderness, petechiae, and swelling are noted on occasion.

Laser

There is no overall consensus on the type of laser for endoscopic-assisted laser lithotripsy [7]. Laser causes cavitation fragmentation assisting stone extirpation transluminal after application of laser lithotripsy. Ho/YAG laser at pulsed setting with a 2080 nm wavelength carried in a fiber diameter as small as 200 micrometers is well documented [7]. There are no major contraindications other than poor visibility and iatrogenic injury to adjacent soft tissues in large stones in intraluminal deployment.

Endoscopic-Assisted Surgical Procedures

Sialoliths between 4 and 5 mm diameter are amenable to sialoendoscopy. Larger stones (> 7 mm) in the parotid region can be fragmented by ESWL with higher success rates as compared to larger ones in submandibular gland. So endoscopic-assisted surgical extirpation of large stones is commonly employed for fixed, multiple large, palpable and intraparenchymal stones. A transcutaneous approach either via modified facelift and transoral sialodochoplasty for parotid and submandibular gland, respectively, can be performed [7].

If an endoscopic-assisted approach is undertaken in a preauricular/rhytidectomy approach, then a salivary stent in
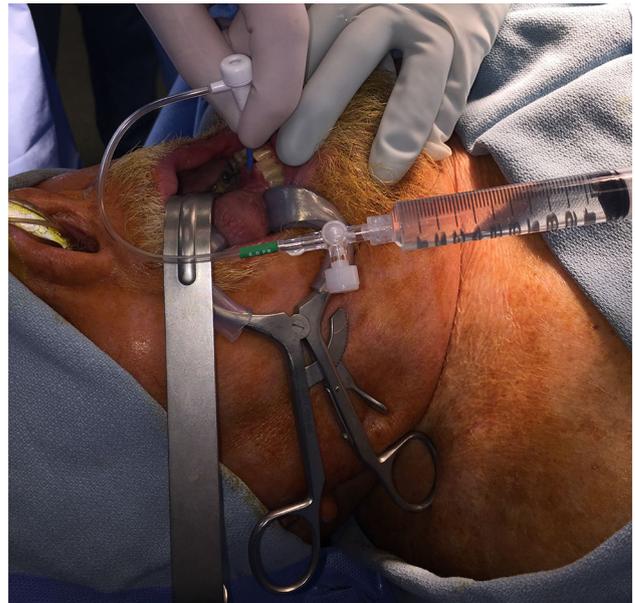

Fig. 4 This figure represents the mouth gag/mouth opener and tongue retractor aiding adequate access to perform the catheterization

the Stensen duct is placed and oral orifice anchor sutures are secured along with docotomy repair.

Technique

Supine positioning and aids to achieve access with mouth gags and tongue retraction are depicted in the illustration Fig. 4.

Identification and characterization of papilla are important. First, visualize the ductal papilla in the floor of the mouth or buccal mucosa. Irrigate gently as necessary with no pressure or stretch on the surrounding tissue. A punctate dark spot is seen occasionally. The duct is dilated with care using the metal finger dilators shown in the Fig. 5. The smallest dilator is on the left with #0000 and increasing in size to the size 6 which is located at the right of the image (0000, 000, 00, 0, 1, 2, 3, 4, 5, 6). Care is to be taken not to dilate past 1.5 cm so not to create damage to the duct or create a false passage.

Some kits come with a special toothed grasper and are atraumatically used to advance the dilators and introducers (Fig. 6). After dilation, a guidewire can be passed into the duct lumen.

Cook Dilator System

The nonmetallic *cook dilator* depicted in Fig. 7a, b is placed over the guidewire to further dilate the duct. The dilator is removed and placed through the *Kolenda*

Fig. 5 Marchal Dilator System, fingerheld Probes-blunt ended sequential sized *fingerheld* instruments with four sizes, (a) 0, (b) 00 (c) 000 (d) 0000. Then 1–6. The set includes set of dilators of increasing diameter from smallest (No. 0000) to largest (No. 6), used for graded dilation of salivary duct papilla. Fingerheld dilators beginning with the #0000 on the left and increasing in size to the size 6 which is located at the right of the image
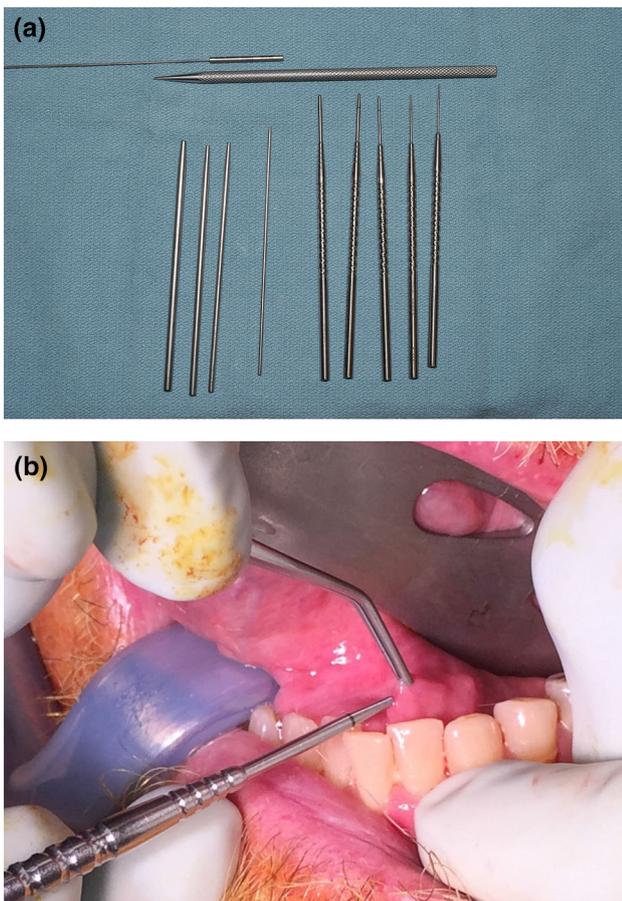

Fig. 6 a Handheld dilator and bougies for sequential dilation. **b** Use of atraumatic forceps to grab the duct orifice and introduce the dilator. These dilators have a black ring along with numbers to identify the sequential increase in diameter

Introducer Set which is then collectively threaded over the guidewire. See Fig. 7c.

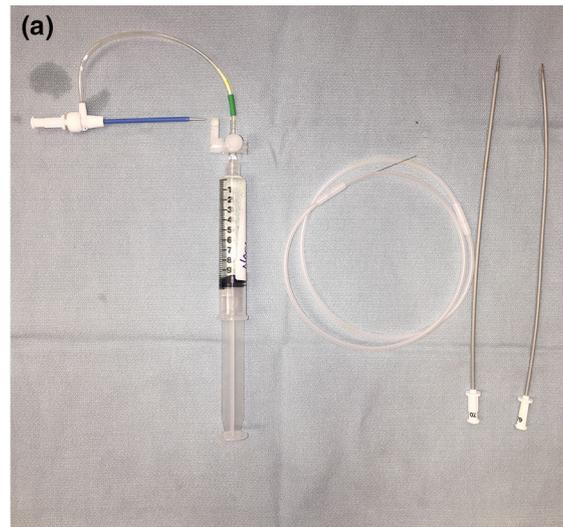## Kolenda Introducer Set-Threaded Over a Guide Wire

The guidewire and dilator are then removed to allow for placement of the 1.1 mm Storz scope. The scope is placed in the introducer and occasionally due to a proximal stone/ stricture can have resistance and may be unable to advance given contact with obstruction.

Intraductal Pictures (Fig. 8a–d)

Ductal strictures and scars can be dilated by sequential instrumentation or using balloons. The balloon and the pressure gauge is depicted in Fig. 9. This can be performed in adjunct to the endoscopy procedure or as a therapeutic intervention of duct dilation for autoimmune strictures.

Stone retrieval basket with stone at the end used through the working port for extirpation of stone with direct visualization (Fig. 10).

Nahlieli and Nazarian [6] describes a retropapillary technique if these structures (papilla or duct orifice) are not identifiable. A mucosal incision on the floor of mouth medial to the sublingual gland is performed to identify the duct. Then, the duct is incised to a 1-mm diameter to introduce the endoscope. Papillotomy can be performed to overcome orifice stenosis and should not be more than 3–4 mm. This is to prevent restenosis and cicatrization. The papilla is dilated with conical tapered salivary duct dilators. These are 14 cm long (see dilators- finger and handheld in pictures) and come in eight different sizes for serial dilation. Once the dilator is placed, topical local anesthetic solution can be used to anesthetize the duct if the patient is being operated under local anesthesia or in a monitored care anesthesia setting. Anesthesia is noted to help with the relaxation of the periductal musculature prior to instrumentation. The main emphasis of any intraluminal procedure is continuous active nonpressurized irrigation. The endoscope connected to the catheter helps keep the collapsible duct in the patent state for better visualization and instrumentation. The endoscope can be carried all the way to the second and third order duct system past the buccinator sphincter and the hilum or the genu of the major duct. Natural constrictions of the duct are termed as " comma area." Please see the table highlighting the "comma area" of the diagnostic procedures could be as short as a few minutes to these interventional procedures lasting as long as an hour.

Kolenda Introducer Set- threaded over a guide wire

Fig. 7 a Introducer, guidewire and dilators (left–right). **b**, **c** The nonmetallic *cook dilator* depicted in (**a**, **b**), is placed over the guidewire to further dilate the duct. The dilator is removed and placed through the *Kolenda Introducer Set* which is then collectively threaded over the guidewire. See (**c**)

Comma Area (Difficult Areas to Explore Access)

Wharton's duct	Around the end of the mylohyoid muscle and the duct genu
Stensen's duct	Lumen narrowing of buccinator passage and duct curvature around the masseter muscle

Discussion

Obstructive salivary gland disease due to mineralized stones causes the majority of salivary ductal-related pathology. Submandibular gland sialolithiasis comprises the majority of cases with less than 10% of obstructive symptoms related to parotid gland.

Contraindications

The only definitive contraindication of sialoendoscopy is active inflammatory or suppurative salivary gland disease. Skill level and access to specialized instrumentation is a relative consideration too [3]. Patients with severe trismus and poor access to endoscopic technique are certainly limitations for these procedures.

Complications

Postprocedural swelling is fairly common. This usually occurs as soon as a couple of hours due to the pressure of irrigation and instrumentation. Instrumentation can lead to false lumen, perforation of the ducts, hematoma, extravasation of the irrigant, and pain in the acute setting. Strictures of the duct, pseudocystic salivary extravasation
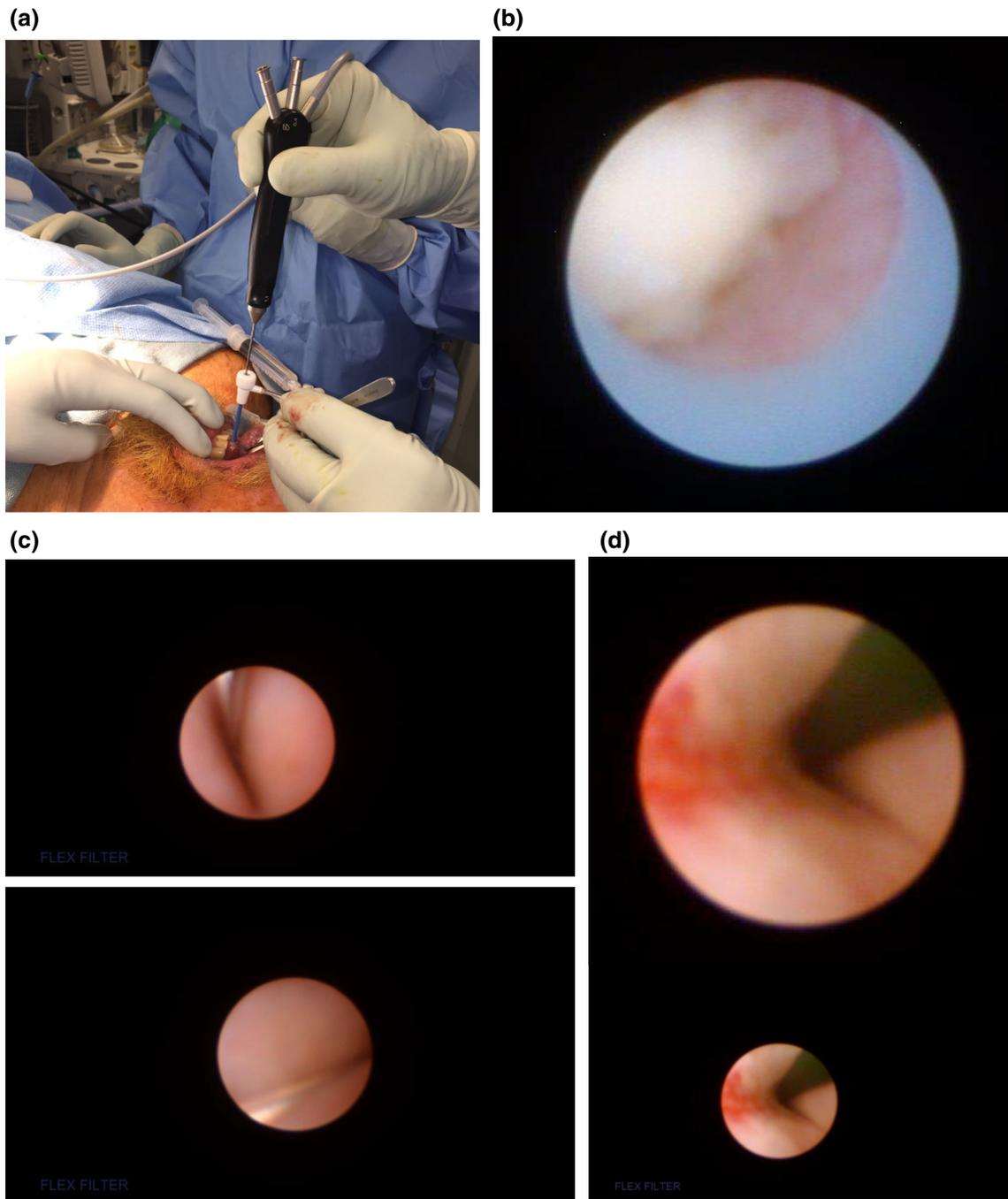
Fig. 8 a A three-channel scope of 1.1 mm diameter used as depicted at the nose of the scope used for instrumentation, working and irrigation. **b** A intraluminal picture of ductal debris and plugs. **c** Camera visualizing the working instrument. **d** Intraluminal visualization of the balloon dilator and ductal erythema with higher magnification to rule out iatrogenic trauma

phenomena of ranula, neuro-injuries of the lingual and the facial nerve are all documented [7]. Instrument breakage and fragmentation is possible and is an indication for endoscopic procedure.

Complications can be broadly categorized to patient-related and instrumentation technique. Acute inflammatory, symptomatic intraparenchymal stones, severe distal duct stenosis, coagulopathy, poor patient follow-up and additional patient-related contraindications in addition to those previously described. Instrumentation-related complications are ductal trauma, lacerations, ruptures, scarring strictures and infections. Gland swelling papillary infection is the highest at about 23%. All other complications are

Fig. 9 Balloon dilator at the bottom of the picture is available with a pressure gauge for duct dilation. Once past the sialolith, balloon inflated to 8 atmosphere pressure, held for 30 s, deflated to 4 atmospheres, and pulled through the duct. Copious irrigation can be applied through the port too flushing out thick mucus plugs

obstructive and stricture therapy in deeper areas are challenging along with combined intra- and extra-luminal approaches.

Summary

The future of salivary endoscopy lies in excellent simulator training of surgeons. Advances in flexible optics and 3D reconstructions make virtual surgery a good tool in diagnostic and interventional transluminal procedures. Developing Magnetic Resonance spectroscopy and sialography with reconstructions can aid in better diagnosis.
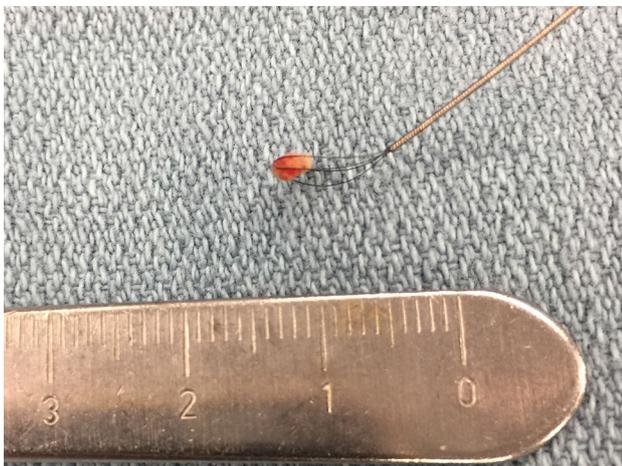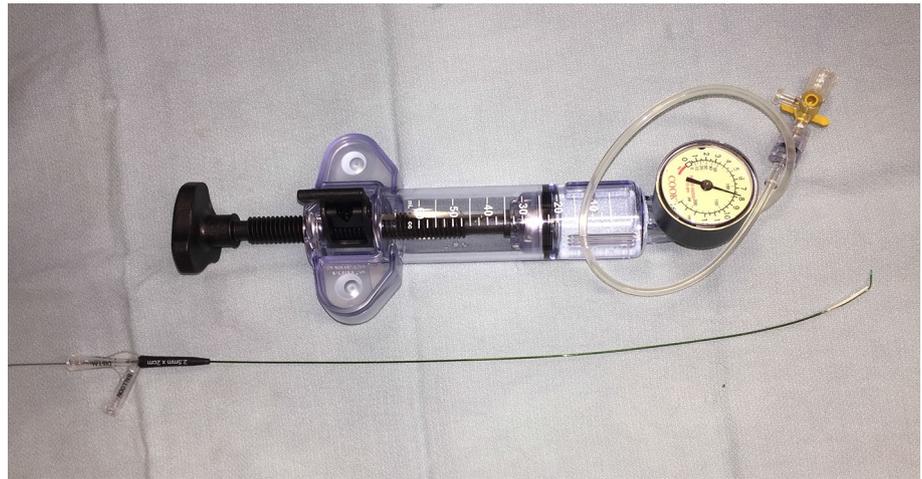

Fig. 10 Stone retrieval basket with stone at the end is demonstrated below

less than 5% and include injury to nerves, strictures and salivary fistulas.

Considerations for Success in Sialoendoscopy

1. Size
2. Site—parotid versus submandibular and ductal pathology location
3. Situation—obstructive, stenosis, generalized autoimmune
4. Shape—stone(s) and lumen shape
5. "Shaking"—mobility of stones
6. Serial instrumentation

Case selection in the initial stages of training is critical. Adequate diagnostic endoscopic skills and smaller stone management is attained. Then, progression to larger stones and fibrosed gland management is undertaken. Total

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