Submandibular Stones

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Key Points

1. Gland preservation techniques are associated with lower morbidity, reduced blood loss, better cosmesis, and reduced hospital stays.
2. Gland-preserving surgery incorporates sialendoscopy that can be combined with transoral procedures that allow access or stone removal.
3. An understanding of the anatomy of the floor of the mouth especially the sublingual gland, Wharton's duct, and lingual nerve is vital to being prepared to manage salivary gland stones.
4. Palpable stones in the anterior floor of the mouth can be managed with simple transoral removal.
5. Anteriorly located stones can be treated with sialendoscopy alone.
6. Small and intermediate stones can be treated endoscopically or with lithotripsy. Larger stones or impacted stones will require hybrid techniques.
7. An understanding of how to manage the duct, options and indications for stenting, as well as ability to recognize complications are all important for good outcomes.
8. Large stones with difficult transoral access may benefit from the technological advances provided by robotics.
9. Most importantly, understanding the patient's symptoms and expectations and tailoring the approach to meet these expectations will result in most optimal outcomes.
10. An astute sialendoscopist must always have a high index of suspicion for neoplastic processes which can occur occasionally in sync with nonneoplastic disorders like salivary stones and occasionally present with similar complaints.

Electronic Supplementary Material The online version of this chapter (https://doi.org/10.1007/978-3-319-58335-8_6) contains supplementary material, which is available to authorized users.

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Introduction

Sialolithiasis is a disease of the salivary gland characterized by the mechanical obstruction of the salivary duct by a calculus. The incidence of sialolithiasis in the general population has been reported to be 1.2% [1]. Salivary stones are most often seen in the submandibular gland (80–90%) as compared to the parotid gland (5–20%). Stone formation in the sublingual and minor salivary glands is very rare.

M.B. Gillespie et al. (eds.), *Gland-Preserving Salivary Surgery*,
https://doi.org/10.1007/978-3-319-58335-8_6

The predominant prevalence of salivary stones in the submandibular gland can be explained by anatomic factors such as the longer, ascending tract of the submandibular duct, as well as the more alkaline and mucous composition of the saliva, which contains higher concentrations of calcium and phosphate.

Sialoliths can vary in size from less than 1 mm to a few centimeters in diameter. Eighty-eight percent of salivary stones will be less than 10 mm in diameter, with a majority being within 3–7 mm in diameter. In a small percentage of cases, salivary stones will grow to sizes greater than 15 mm. The majority of stones are located in the hilum or proximal duct system (53%), followed by the distal two-thirds ductal system (37%) with only 10% in the intraparenchymal duct system [2]. While small stones sometimes pass out of the duct on their own, larger stones typically remain in the gland or duct until removed.

Historically, surgical treatment for patients with symptomatic sialolithiasis involved papillotomy for distal stones and submandibular gland excision for proximal or intraglandular stones. Although sialoadenectomy is the definitive treatment for obstructive sialadenitis, it is associated with higher rates of complications including permanent nerve damage (marginal mandibular, lingual, or hypoglossal nerves), salivary fistula, sialocele, and aesthetic consequences. It was previously believed that a gland with sialolithiasis becomes nonfunctional. This has been disproved with studies showing a return to normal secretory function following stone removal, as well as normal histologic findings in glands removed for sialolithiasis, further justifying gland-preserving approaches [3].

Sialendoscopy is a technique that allows endoscopic visualization of the submandibular ductal system and facilitates minimally invasive management of stones, thus allowing for gland preservation. The management of salivary stones in the submandibular gland often involves endoscopic and endoscopic-assisted transoral procedures to allow gland preservation.

Clinical Presentation

Salivary stones are the commonest cause of unilateral submandibular gland swelling. The patients can be completely asymptomatic who are diagnosed incidentally during imaging for other diagnoses or can present with the classical symptoms of swelling of the gland during meals. Glandular swelling can be painless or painful. Mechanical obstruction of the submandibular gland can be complicated by bacterial infections resulting in acute sialadenitis with purulent salivary secretions and an enlarged painful gland that can also progress to abscess formation (Fig. 6.1). In most cases, however, patients present with chronic symptoms of intermittent swelling that resolves spontaneously. Consequently, a past medical history of chronic sialadenitis may suggest sialolithiasis. Other histories relevant during initial evaluation include a history of dry eyes and dry mouth that could be associated with Sjogren's syndrome, diabetes mellitus, or dehydration, all of which may predispose the patient to calculus formation. Gout has also been found to be associated with sialolithiasis, in which case crystals will be made up primarily of uric acid.

Fig. 6.1 Right submandibular papilla is obstructed with corresponding inflammation of the anterior floor of the mouth with a large distal sialolith and purulent secretion at the papilla

Other relevant history that impacts the management of stones is a history of bleeding disorders, autoimmune diseases, or medications that lower salivary production (see Chap. 1). Tobacco use is shown to be positively correlated with sialolithiasis [3].

Physical Examination

All new patients must have a thorough and complete head and neck examination to rule out a coincidental neoplastic process. Oral cavity examination should include an inspection of all the four salivary duct openings. The submandibular duct can open on the papilla as a singular opening or at times multiple openings. Consequently, the opening of the duct, site, and patency must be documented for easier identification during surgery. Also, if the submandibular papilla is difficult to identify or expression of saliva on ipsilateral gland massage does not produce saliva, this may indicate obstruction of Wharton's duct or papillary stenosis. Accordingly, access to the papilla can be planned accordingly, i.e., the surgeon can have a lower threshold for performing a sialodochotomy during sialendoscopy, if all techniques to identify the papilla have failed. It may also influence the choice of anesthesia for the operation. Bimanual palpation of the floor of the mouth should be performed to identify the location of the stones if palpable, and also posterior floor of the mouth palpation must be performed to assess access to the hilum for management of larger hilar stones via combined approach technique. For stones that are not palpable, an in-office ultrasonography can be helpful to identify stones, gauge mobility of the stones under ultrasound, and localize them with sonopalpation, which is US combined with transoral stone palpation. Tenderness to palpation of the floor of the mouth, erythema, and purulence from the salivary duct all denote an acute suppurative sialadenitis. In the latter situation, active surgical intervention or endoscopic intervention is usually contraindicated as the risk of duct penetration is high during acute infection. Surgery, open and endoscopic, is usually deferred until the patient's active infection has resolved. Neck examination should also be performed to assess the submandibular gland tenderness, firmness or induration, and size. Obstructed salivary glands may be enlarged, but chronic sialadenitis can also result in atrophic glands. Firm fibrotic glands can be indicative of chronic infection or inflammation. Bilateral gland pathology often points to a systemic etiology, i.e., Sjogren's syndrome, sarcoidosis, or IgG4 sialadenitis.

Imaging

The common imaging techniques used for submandibular stones include ultrasound (US) and computerized tomography (CT) imaging. Plain X-rays or orthopantomograms are fast and noninvasive; however, these often miss intraglandular or small stones; in addition, only 80% of submandibular stones are radiopaque on plain films. The sensitivity for other imaging modalities is higher. Ultrasound imaging can locate stone greater than 2 mm in size. Stones smaller than 2 mm can be missed. There are also certain areas such as the anterior floor of the mouth which are not easily assessable on US, consequently resulting in the possibility of missing pathology. US is helpful not only in clinical diagnosis but also has implications in surgical management, i.e., intraoperative localization of stones via sonopalpation; it is, however, highly operator dependent. Other advantages of US are that it allows avoidance of exposure to radiation, and it is repeatable, inexpensive, and efficient. A study comparing US, sialography, and endoscopy demonstrated sensitivity of 81%, specificity of 94%, and accuracy of 86% for US.

In the United States, US is gaining popularity to diagnose and manage salivary gland disease; however, computerized tomography (CT) scans are probably more commonly ordered to determine salivary gland pathology. The authors recommend CT scan with 1 mm cuts both with and without contrast to evaluated submandibular sialolithiasis. CT imaging is ideal to get a broader

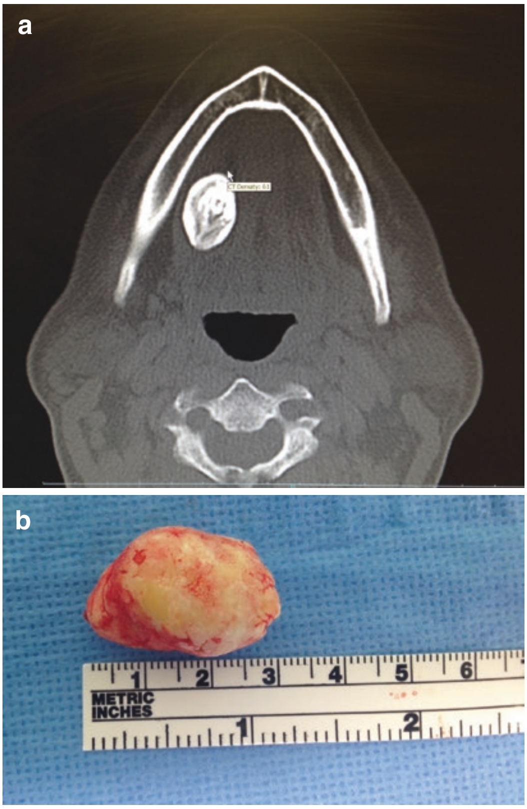

Fig. 6.2 (**a**) CT scan showing a large right submandibular duct stone with hilar involvement. (**b**) Right submandibular duct "megalith"

perspective of submandibular stone presentation. CT scans help identify the location, shape, size, and number of stones which may not be readily visible on US (Fig. 6.2). The disadvantage is that the ductal pathology can only be interpreted indirectly, i.e., ductal stenosis or obstruction by proximal ductal dilation. Also, CT images are not dynamic, i.e., stones can move in location from the time when a scan is done to when the patients undergo therapy consequently not providing real-time information on stone location.

Sialography is an excellent imaging tool to determine ductal pathology. Identification of ductal stenosis and extent of stenosis can be determined with sialography. Disadvantages include irradiation, pain associated with the procedure, possibility of ductal perforation, and pushing the stone further proximally in the gland. Also MRI and MRI sialography can provide valuable information; they are uncommonly necessary for management of submandibular stones. When there is concern regarding the presence of a coexisting pathology, i.e., tumor or autoimmune disease, MRI imaging can be a valuable. MRI sialography consists of 3-mm T2-weighted fast spin echo slices, performed in sagittal and axial planes. Volumetric reconstitution is performed, allowing visualization of the ducts. It is a rapid, noninvasive technique without dye injection and possibility to visualize all major salivary glands; however, cost of the procedure, longer time required for image reconstruction, and difficulty for claustrophobic patients limit the use for routine imaging of submandibular stones.

Indications for Sialendoscopy

Sialendoscopy should be considered in all cases of submandibular sialolithiasis in patients who have obstructive symptoms and for diagnostic evaluation of recurrent unexplained swelling of the submandibular gland associated with meals. Patients with history of recurrent acute sialadenitis with or without abscess formation also qualify for stone removal. Patients diagnosed with sialolithiasis incidentally or who are not particularly symptomatic should be given the option of observation as well. However, pros of this observation protocol, i.e., avoidance of surgical complications and cons, i.e., possibility of recurrent obstructive symptoms, acute sialadenitis, neck abscess, and also loss of ability to offer endoscopic interventions as smaller stones may increase in size (rate of growth 1 mm/year), must be discussed with the patient.

Contraindications to Sialendoscopy

There are few contraindications for sialendoscopy. In patients with medical issues precluding administration of general anesthesia, the procedure can be performed under local anesthesia with sedation. However, some patients may be medically unfit for any invasive procedure and can be observed. Active sialadenitis is a relative contraindication; sialendoscopy is more difficult in setting of inflammation, and intervention can result in higher changes of ductal injury including perforation and stenosis.

Surgical Techniques for Management of Submandibular Stones

External lithotripsy is an option for the management of sialolithiasis and is discussed in Chap. 5 (Parotid Stones). Our discussion on management of submandibular stones will focus on current philosophies and technical considerations of various gland-preserving techniques for management of the submandibular stones.

The algorithm for stone management as defined by Marchal et al. takes into consideration stone size. Small stones (≤4 mm) can be accessed endoscopically, and large stones (≥6 mm) can be managed using combined approach techniques or removal after stone fragmentation. Intermediate-sized stones are challenging and often need a combination of endoscopic and open techniques to locate and treat them. Studies have shown that other than stone size, location, shape, and orientation are helpful in determining the likelihood of endoscopic success.

Preoperative Preparation and Considerations

As described earlier a thorough head and neck examination is mandatory prior to intervention in the operating room. Equally important is the importance of the informed consent. Chapter 1 discusses the nuances of examination and evaluation of patient with salivary gland disorders. Discussing the procedure in detail including expectations, complications, need for insertion of stents vs. not, postoperative recovery, and days of work lost are important aspects of preoperative preparation. A discussion with the anesthesiologist to plan endotracheal tube placement is important. If the procedure is being performed under general anesthesia, nasal intubation offers a wider exposure of the oral cavity, but there is a risk of epistaxis. In most cases, especially with experience, oral intubation will provide adequate exposure and access to the anterior and posterior floor of the mouth. In patients undergoing bilateral procedures, nasal intubation is preferable. Also it's important to avoid anti-sialagogues such as Robinul (glycopyrrolate). Availability of preoperative imaging or access to US for intraoperative intervention should be considered. In patients who are undergoing combined approach or hybrid procedures, external pressure on the submandibular gland is vital in propping up the floor of the mouth contents. In some cases, especially in patients with challenging access to the oral cavity (e.g., obese patients, small mouth opening, tori, or large teeth or tongue), the need for two assistants may be necessary. Consequently, pre-op planning for adequate intraoperative assistance is vital to success.

Operative Planning Issues

Anesthesia:

- General anesthesia or local anesthesia with sedation.
- If performed under general anesthesia, recommend oral or nasal intubation with muscle relaxation for better intraoral access.

Positioning:

- Supine.
- Intraoral and extraoral Betadine prep may be considered.

Perioperative antibiotic prophylaxis:

- Perioperative administration of antibiotics to cover the oral flora is recommended.

Monitoring:

- Routine anesthesia monitoring

Instruments and equipment to have available:

- Head and neck set
- Monopolar and bipolar electrocautery
- Intraoral retractors:
  - Disposable plastic cheek retractors.
  - Jennings retractors, Minnesota retractors, and dental props are all useful in providing intraoral exposure.

- Salivary duct dilators and stent for cannulation of Wharton's duct:
  - Marchal or Schaitkin dilator systems (Karl Storz, Germany)
  - Disposable dilator systems (Cook Medical, USA)
  - Salivary duct stents (Hood Laboratories, Pembroke, MA)
- Sialendoscopy tray
- Sialendoscope(s) and video tower:
  - Most commonly the "all-in-one" interventional endoscopes are favored due to their versatility in diagnostic and interventional procedures.
- Disposable instrumentation:
  - Stone baskets
  - Indwelling access sheaths
  - Laser (holmium) for lithotripsy and laser fibers
  - Pneumatic lithotripter (Cook Medical, USA)

Prerequisite skills:
- Experience with salivary gland and salivary duct surgery

Operative risks:
- Risks of general anesthesia.
- Bleeding.
- Infection.
- Ductal injury, i.e., perforation, avulsion, or scarring (stenosis).
- Stenosis of the papilla.
- Salivary fistula is not a major complication as the salivary fistula into the floor of the mouth is desired. However, in some cases, salivary leak and fistula due to injury of the sublingual duct and gland can lead to post-op sialocele or ranula formation.
- Lingual nerve injury.
- Inability to remove stone.
- Need for further procedure to remove submandibular gland.

Surgical Approach and Techniques

Exposure to the oral cavity is obtained using a variety of retractors. Disposable cheek retractors are vital in providing lateral exposure by retracting the buccal mucosa; this is especially relevant for submandibular stone management. The retractor tends to block access to the parotid duct and consequently is not as often used for exposure in parotid cases. General anesthesia with oral or nasal intubation is performed. Sedation with local anesthesia can be substituted if preferred or if general anesthesia is contraindicated. Bite block and oral retractors (e.g., Jennings retractor) are placed for adequate intraoral exposure.

Access to the Submandibular Papilla

This is the rate-limiting step for submandibular sialendoscopy. The submandibular papilla is first identified under magnification and then sequentially dilated. Identification is facilitated by preoperative identification and localization of the papilla. Intraoperatively, pressure on the gland externally will allow the papilla to be identified by egress of saliva from the opening. In difficult cases, application of methylene blue to the floor of the mouth can help make the papilla more prominent. Once identified, the papilla can be dilated using a variety of dilating systems and techniques. Most experts advocate a "no-touch" technique, i.e., to avoid using toothed forceps to grab the floor of the mouth mucosa which may create illusions of a papilla by the punctures created and also increase risk of maceration of the papilla. Retraction of the floor of the mouth can be performed bluntly using Q-tips or retractors (finger retraction or metal). Once the duct is cannulated, dilation must be performed of the first 1.0–1.5 cm of the duct opening; more distal introduction of dilators can cause stones to be pushed back toward the hilum or traumatize the duct. In general, dilation should be smooth and atraumatic. If excessive resistance is felt, a stenosis or false passage should be suspected. Dilation techniques essentially include either serial dilation using metal dilators of increasing caliber or dilation over a guide wire, i.e., Seldinger technique using either non-disposable metal or disposable cannulas. After appropriate dilation, the sialendoscope is inserted, and endoscopic localization of the stone is performed.

In cases where access cannot be obtained using standard dilation techniques, a sialodochotomy and repair of the duct are indicated. This can be performed either by incising the papilla and proximal duct and suturing this to the floor of the mouth or by leaving the natural papilla intact and instead making a sialodochotomy about a centimeter proximal to the natural opening. In the latter alternative, the duct is then marsupialized to the floor of the mouth creating a new opening for the duct; the advantage is that the natural papilla is maintained, and consequently the duct remains tethered anteriorly to the floor of the mouth giving stability to the duct. The disadvantage is the possibility of injuring the sublingual duct opening and increasing the chances of ranula formation.

Fig. 6.3 Floor of the mouth duct marsupialization

Anterior Floor of the Mouth Stones or Stones at the Papilla

For stones at the papilla, usually a simple transoral stone removal is adequate. This can be performed in the office or in the operating room under local or general anesthesia, depending on size of stone, palpability of the stone, patient preference, and surgeon comfort. The stone is usually fixed in place using a hemostat or forceps. A papillotomy can be made to release the stone; usually this is followed by egress of obstructed saliva. A small papillotomy usually will heal well without need for stent placement. Flow of saliva serves as a stent in this case; consequently, salivary gland massage, hydration, and sialagogues are important to help prevent papillary stenosis. If additional stones are suspected, a sialendoscopy can then be performed at that time both for diagnosis and treatment.

Anterior floor of the mouth stones impacted in the submandibular duct are also managed in a similar fashion. The position of the stone away from the papilla brings on a few challenges. How do you manage the duct? Is the sublingual gland at risk? Is stent placement necessary? Is an endoscopy necessary? For palpable anterior floor of the mouth stones, if the duct can be accessed, an endoscopy is performed to visualize the stone; in many situations, if the stone is favorable in orientation, it can either be captured in a basket or with a forceps and retrieved to the level of the papilla, after which a papillotomy is needed to help deliver the stone. If the duct cannot be accessed, then the stone is removed by making a floor of the mouth incision and sialodochotomy (Fig. 6.3).

When endoscopy is possible, it should be performed; even when the stone is impacted in the duct, having an endoscopic view of the stone is helpful both for stone localization and subsequent endoscopy to check for additional stones, fragments, and for stent placement. If the natural papilla and distal duct are normal, stenting after removal of large mid-duct stones can be considered to allow for a more natural flow of saliva. The sialodochotomy is either closed or left to heal around the stent. The floor of the mouth incision is usually closed with interrupted absorbable sutures. However, this is not mandatory, given that the saliva must drain into the oral cavity, the sialodochotomy can be matured to form a second opening for the duct into the floor of the mouth. As mentioned earlier, a side effect of ductal manipulation is ranula formation; patients must be counseled about the possibility for ranula formation and need for additional surgery. In situations where Wharton's duct is widely marsupialized, injury to the sublingual duct is a high probability. Some authors recommend an elective sublingual gland excision to prevent the complication of future ranula and also to facilitate suturing the duct to the floor of the mouth mucosa by removal of intervening minor salivary gland tissue.

Small- and Intermediate-Sized Stones

Intraductal mobile stones are ideal for endoscopic retrieval. A variety of endoscopic tools can be used to facilitate stone removal, i.e., stone baskets and stone forceps. The intermediate-sized stones provide a unique challenge to the sialendoscopist. These stone are too large to permit endoscopic removal unless they are favorably oriented and too small to be easily palpable in the floor of the mouth and consequently amenable to a combined approach procedure. Often stones within the duct may have a preceding stenosis that must be dilated or managed prior to an attempt at stone removal.

Intermediate-sized stones can either be observed if endoscopic access is not ideal or fragmented to allow piecemeal removal of the stone. These procedures may be lengthy and necessitate multiple passes of the endoscope, dilators, and instruments to permit stone removal. The length of the procedure and manipulation of the papilla and duct may cause ductal edema and injury. Endoscopic indwelling access sheaths can be used to minimize the ductal injury and provide a stable operative channel for intervention.

Fragmentation of the stone can be performed in one of several ways, often depending on the consistency and hardness of the stone. Some stones tend to be more resilient to mechanical pressure than others. The handheld micro-drill and forceps are options where mechanical energy can be used to fragment stones. This is combined with endoscopic retrieval of fragments. The micro-drill is ideally suited for stones at the hilum where the drill can be used to fix stone to the hilar wall to facilitate fragmentation. Stone forceps can be used to crush stones; however, the success of this method depends on the stone integrity and size. Large, spherical, and hard stones are not amenable to being fragmented by this method. Laser lithotripsy has been used to fragment stones. The Holmium laser, which is a contact laser, is ideally suited for this purpose. However, inherent problems with the use of lasers include line of site view, i.e., the laser fiber can only be used and activated if a clear view of the stone can be obtained. Laser energy although effective in lithotripsy causes lateral thermal damage that can predispose the duct to stenosis. Lower-energy settings allow a more controlled breakdown of stones but also take longer operative time predisposing the duct to edema. In addition, the tip of the laser generates heat that could also damage the salivary endoscope. For these reasons, although effective, laser lithotripsy has been adopted in a limited fashion in most practice setting. Other regulatory hurdles include off-label use of the laser for salivary stones and need for hospital credentialing for the use of holmium laser; the holmium laser is most often used in urologic procedure and has limited ENT indications which sometimes makes it difficult for otolaryngologists to get adequate experience to fulfill institutional credentialing criteria.

Intraductal lithotripsy has been investigated in the past with limited success. However, recent studies with a newer pneumatic lithotripter device have shown promising results for stone fragmentation. The device is coupled with the use of the indwelling operative sheath and a salivary duct irrigator (SialoCath™, Cook Medical, USA) to create an all-in-one system for intraductal lithotripsy, stone fragmentation, and removal of stone fragments.

After complete stone removal in these scenarios, irrigation of the duct with steroid-based solution and stent placement may be a consideration depending on the surgeon’s concern for ductal trauma, edema, and post-op stenosis.

Large Hilar Submandibular Stones

Stones that are not amenable to endoscopic removal or fragmentation can be removed from combined approach or hybrid techniques. The principle of these techniques is to use a combination sialendoscopy with open techniques to facilitate gland preservation. Endoscopic localization is combined with transoral stone removal to guide dissection, perform a check endoscopy after stone removal, and facilitate stent placement if deemed necessary. Ultrasonography can also be a valuable adjunct to stone localization with sonopalpation. If the stone is trapped within a wire basket and endoscopic retrieval is not possible, the procedure can be converted to a combined technique wherein the trapped stone is secure and stable in position within the basket to complement transoral removal. If not trappable, the scope is replaced with a ductal dilator to allow for constant duct localization without risk to the scope from retractors. The understanding of the posterior floor of the mouth anatomy is vital to this technique. The lateral relation of the lingual nerve to the hilum of Wharton's duct as it passes over the nerve is important to visualize three-dimensionally. In some cases, the lingual nerve needs further mobilization and medialization to get a more direct view of the hilar portion of the duct. It is also important to realize the posterior portion of the sublingual gland may obscure the view of the posterior Wharton's duct, lingual nerve, and medial pterygoid muscle and often needs to be excised to provide necessary exposure for sialodochotomy (Fig. 6.4a, b).

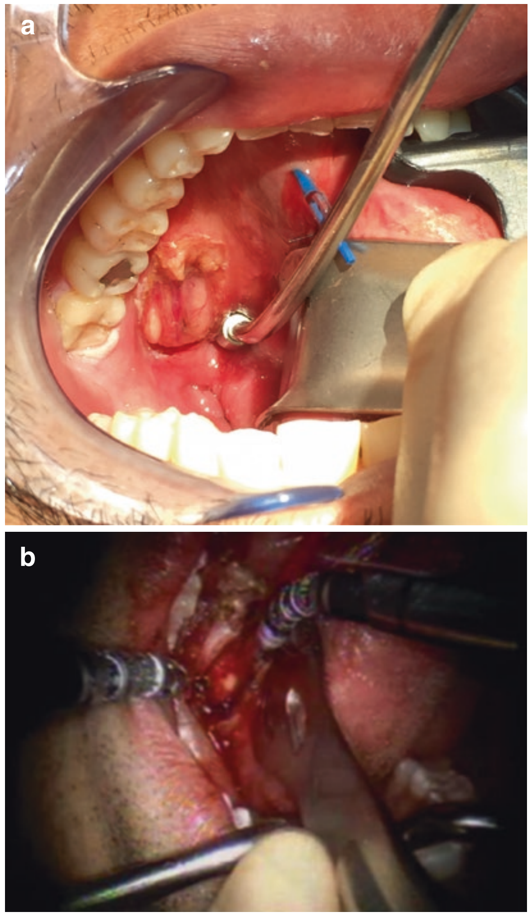

Fig. 6.4 (**a**) A posterior floor of the mouth incision showing posterior sublingual glandular tissue obscuring the view of the submandibular duct and lingual nerve. This must be excised to visualize the posterior floor of the mouth structures. A 1.2 mm WS stent in place to help localize the duct. (**b**) End-on view of robot-assisted stone removal showing the relation of the submandibular duct with hilar stone (medially) and lingual nerve (laterally) in the posterior floor of the mouth

An assistant provides elevation of the gland toward the floor of the mouth. An intraoral incision is made in the floor of the mouth over the stone guided by transillumination, palpation of the stone itself, or the stone basket combination. The stone within the duct and the lingual nerve are localized primarily via blunt dissection. With the lingual nerve in view, the duct is incised over the stone and the stone is delivered. Dissection of the stone from the walls of the duct is often necessary to free the stone completely. Extension of the ductal incision may be necessary to deliver a large stone or megalith (≥15 mm). It must be borne in mind that the ductal lumen is smaller distally and anterior extensions of the sialodochotomy may lead to subsequent stenosis; stent placement may be reasonable in this is a concern. Similarly, posterior extension of the ductal incision brings the incision closer to the lingual nerve as it crosses the duct, and care must be taken to avoid injury to the nerve.

Salivary endoscopy is performed to check for additional stones and to remove stone remnants which will lead to recurrence. The Wharton's duct is repaired or stented when possible. There is no evidence to suggest that a formal repair or stenting of the duct avoids subsequent stenosis and consequently correlates with long-term gland preservation, salivary gland function, or symptom resolution.

Salivary Duct Stenting

Stenting of the salivary duct for the submandibular glands is controversial. Stenting is not evidence based but is usually considered when postoperative ductal stenosis after papillotomy, sialodochotomy, interventional sialendoscopy, or combined approach technique is considered to be possible based on clinical judgment. A variety of existing devices have been modified or used as alternatives for stenting such as infant feeding tubes, angiocatheters, dilators, and access sheaths meant for salivary duct access that are used to fashion stents. Stents specifically designed for short-term intubation of the salivary ducts are also available commercially (Walvekar Salivary Duct Stent, Schaitkin Salivary Cannula; Hood Laboratories, Pembroke, MA) (Fig. 6.5).

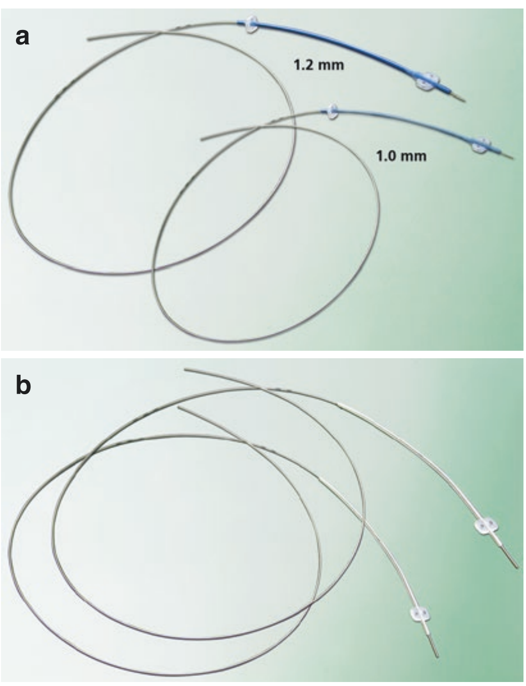

Fig. 6.5 (**a**) Walvekar Salivary Stent with guide wire (Hood Laboratory, Pembroke MA). (**b**) Schaitkin Salivary Duct Cannula (Hood Laboratory, Pembroke, MA)

Postoperative Issues

Routine Postoperative Management

The majority of patients who undergo diagnostic and interventional sialendoscopy can be discharged the same day. If there is a concern for postoperative floor of the mouth edema causing airway distress due to extravasation of irrigating fluid, patients can be observed for 23 h or admitted for inpatient observation. In the authors' practice, patients are discharged with the following instructions:

- Half-strength hydrogen peroxide or chlorhexidine rinse 15 mL TID, after meals, to keep clean if there is a suture line.
- In general, postoperative antibiotics are not necessary. However, if a salivary stent is left in place to manage a damaged submandibular duct, a course of postoperative antibiotics for 10–14 days is recommended. The stent is usually left in place for 10–14 days as well.
- Patients with salivary duct stent placement are asked to inspect the stent for loosening or extrusion daily. If there is a concern for stent displacement, the patients are encouraged to contact the treating team. Other instructions include to avoid massage of the gland since the floor of the mouth elevation during gland massage puts tension on stent anchoring sutures and can cause early extrusion of the stent.
- Follow-up visits are scheduled in 1–2 weeks.

Complications and Management

- *Tongue hypoesthesia due to lingual nerve paresis.* The overall incidence of lingual nerve paresis with combined approach techniques is around 20%. This tends to improve over 4–8 weeks, and symptomatically the patients may feel tongue numbness or experience a metallic taste in the mouth.
- *Bleeding/hematoma*
  - Hematoma requires evaluation and control of bleeding to avoid floor of the mouth swelling and potential airway compromise.

- *Postoperative infection*
  – Incision and drainage, culture, antibiotics, and removal of stent if placed.
- *Wharton's duct injury*
  – Salivary fistula. Often physiologic and does not require treatment

    Duct perforation. If there is a minor ductal injury during endoscopy, this does not need intervention. Once the injury is identified, irrigation must be stopped, and the procedure is aborted.

    In case of a major ductal injury, the procedure is aborted, but due consideration should be given to ductal stenting or marsupialization.

    In case of duct avulsion, a rare complication, usually associated with excessive force being used to deliver a stone trapped in the stone basket, the procedure must be aborted, and gland excision will be necessary.
  – Stricture or stenosis. Sialendoscopy with dilation and stent placement or submandibular gland excision for recalcitrant cases

Discussion

Marchal categorized as small or large stones based on the maximal dimension of the stone, along its length or width that can safely be removed using an endoscopic technique [3]. Small stones, i.e., stones that or 4 mm or less, that are located anteriorly within endoscopic reach, can typically be removed with sialendoscopy alone. Large stones, i.e., stones that are more than 4 mm in maximal dimension, stones that are unfavorably located, or impacted stones often require a combined approach, which incorporates sialendoscopy and open transoral surgery. This method has been shown to have overall good success rates with minimal complications. A retrospective analysis by Schwartz et al. looked at 49 combined approach cases for submandibular sialolithiasis. The success rate was 87% with symptom control in 76%. There were no significant complications, and gland preservation rate was 95% [4].

Stones larger than 15 mm are called "giant stones" or "megaliths" and are relatively rare in occurrence. Traditional management of these has been transoral sialolithomy for ductal and easily palpable submandibular stones and submandibular gland excision for hilar or intraglandular stones. A case series by Wallace et al. described management of megaliths utilizing a combined approach with improved gland preservation rates [5]. Advantages of this method include visualization and localization of the stone using sialendoscopy, along with facilitated lingual nerve identification by transillumination. Other advantages include the capability to perform sialendoscopy after stone extraction to check for residual stone fragments or additional stones, as well as the ability to irrigate and check the site of repair in cases where salivary duct repair is indicated. Robot-assisted transoral removal has also been described in the case of a hilar-intraglandular submandibular megalith, allowing for excellent visualization of Wharton's duct and the lingual nerve [6].

The authors do not routinely repair or stent the salivary duct after stone removal for submandibular cases, in contrast with parotid cases. The rationale being that if the ductal incision fistulized into the floor of the mouth, it would be physiologic. Short-term follow-up outcomes have been encouraging [3]. A prospective study by Woo et al. investigated anatomic changes to the submandibular duct following transoral excision of hilar stones without sialodochoplasty. Sialography at 3 and 12 months showed good anatomic restoration of flow through the submandibular duct in all but one patient (3%), who developed partial ductal stenosis. This patient was noted intraoperatively to have severe adhesions between the stone and the duct [7].

Lithotripsy has also been described for larger stones or stones difficult to reach endoscopically. External lithotripsy involves several sessions and does not involve extraction of fragmented stones; stones are expected to evacuate spontaneously, but remaining debris can serve as a nidus for further calcification and recurrence of sialolithiasis. In Capaccio's study of 322 patients undergoing extracorporeal electromagnetic shock wave lithotripsy for submandibular and parotid stones, the stone was completely eliminated in 45%, while 27% of patients were left with residual stone fragments >2 mm in size. Symptom relief was achieved in 88%. Worse outcomes were associated with submandibular stones and stones >7 mm [8]. Various methods of intracorporeal lithotripsy have been described, with laser and pneumatic lithotripsy techniques being the most common. Holmium laser lithotripsy, while effective, can cause adverse thermal effects by reflection of shock wave energy generated by the laser off of the stone, and concerns exist over ductal trauma and stenosis. A study by Schrotzlmair et al. found that using Ho:YAG laser lithotripsy with energy higher than 500 mJ per pulse was associated with damage to the surrounding tissue [9]. Endoscopic pneumatic lithotripsy using the StoneBreaker lithotripser, which was originally described for use in renal stones, was described in a live porcine model using artificial submandibular calculi, showing effectiveness of the method while avoiding thermal ductal damage [10]. Preliminary studies in a human model have also been favorable [11].

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