Alternatives for the Treatment of Salivary Duct Obstruction

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KEYWORDS

- Salivary obstruction • Salivary calculi • Duct strictures
- Sialendoscopy • Interventional sialography
- Balloon ductoplasty • Stone extraction
- Gland preserving surgery

SALIVARY DUCT OBSTRUCTION ALTERNATIVE TREATMENT OVERVIEW

This article considers the radiologically and endoscopically guided management of benign salivary duct obstruction. Salivary stones and strictures account for most benign duct obstructions.[1] Traditional management has fallen between the conservative approach (gland massage and review) and surgical lithectomy or sialadenectomy. Alternative treatments for these common causes of salivary obstruction have been sought to offer resolution of symptoms without extensive surgery or coexistence with long-term symptoms. Among these minimally invasive techniques, the per-ductal interventions, such as interventional sialography and sialendoscopy, have become firmly established, offering a solution that may be performed as a simple outpatient procedure under local anesthesia in selected cases.

SALIVARY DUCT STRICTURES

Problems and Aims of Treatment

Strictures, most common in the parotid duct, can take several forms: approximately 66% of cases involve a single point lesion; around 33% are multiple point obstructions along the duct (known as sialadochitis) or a continuous band of fibrous tissue forming a diffuse stricture that may extend over a length of several millimeters. The

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Otolaryngol Clin N Am 42 (2009) 1073–1085
doi:10.1016/j.otc.2009.08.011 oto.theclinics.com
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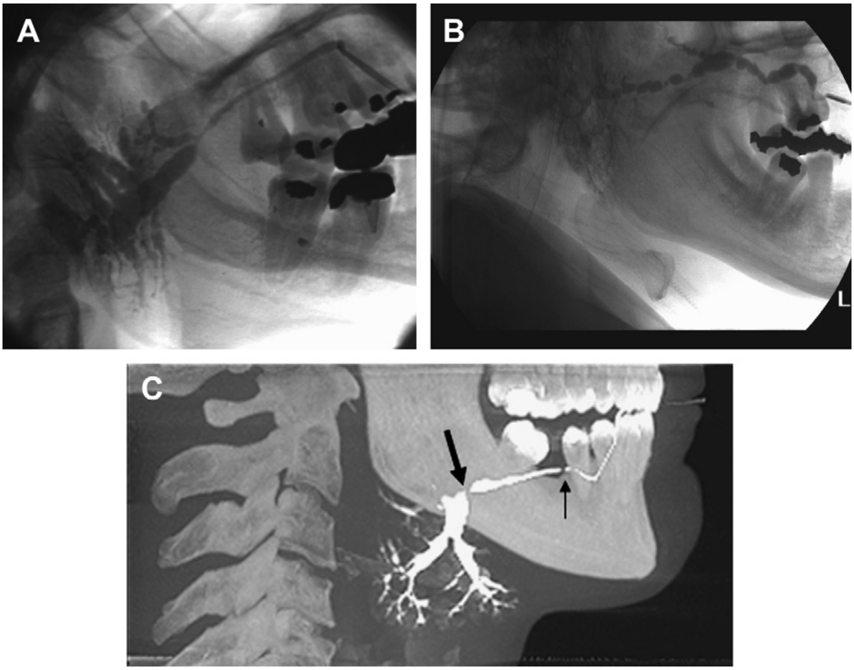

Fig. 1. Parotid sialograms showing (*A*) a diffuse stenosis within the proximal portion of the main extraglandular duct, (*B*) multiple point strictures within the main parotid duct. (*C*) A cone beam computed tomographic sialogram of the submandibular gland showing a small stone in the distal duct (*small arrow*) and a point stricture in the genu region of the proximal duct (*large arrow*).

morphology, number, and position of these strictures is best demonstrated by sialography. This imaging forms the basis for interventional treatment planning (**Fig. 1**).

Sialography demonstrates that the common sites of parotid strictures are at the entry to the hilum of the parotid gland and the point where the duct curves over the anterior border of the masseter muscle to enter the oral cavity.

Endoscopic evidence suggests that evolving strictures, which probably equate to sialadochitis (**Fig. 1**B), commence as fibrous rings in the duct wall, giving it a similar appearance to the lumen of the trachea. Endoscopic examination of duct stenosis demonstrates a condensation of scar tissue within the duct wall giving it a pale, opaque, and avascular appearance (**Fig. 2**).

The clinical manifestation of obstruction is the mealtime syndrome (prandial swelling); but the clinical picture of salivary strictures is different from that of obstruction by a stone. Swelling of the gland does not always occur in relation to food intake; frequently, it is worse on waking, and the symptoms may develop over several days. Sometimes the swelling is released with a sudden gush of saliva. The scarred duct has a tendency to backfill and stagnant saliva has a tendency to gel, so that the ducts are seen to be filled with thick mucous plugs on endoscopic examination (**Fig. 3**). Thus, the probable cause of acute obstruction is a plug washed forward and impacted into a stricture. With time and massage, the plug eventually squeezes through the stricture, followed by a surge of saliva. To minimize the risk of acute obstruction, a constant flow of saliva should be maintained by regular use of sialagogues (chewing gum), supported by regular

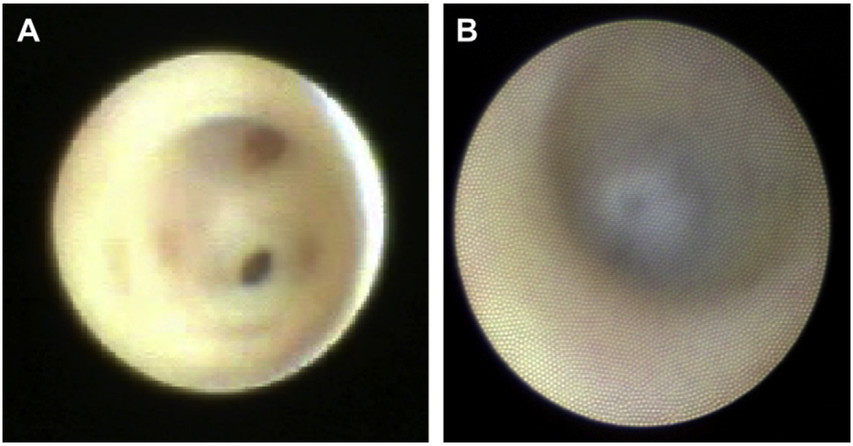

Fig. 2. (*A*) Endoscopic image showing early avascular change within the duct wall and stenosis reducing lumen diameter. (*B*) Endoscopic image showing occlusion of the duct by pale scar tissue.

gland massage. The aim of treatment, however, is to relieve stenosis and thus allow free outflow of saliva, preventing the formation of mucous plugs and allowing any that do form to be expelled readily.

Management of Salivary Strictures

Acute obstructive symptoms can be managed by stricture dilation, which can take several forms. Modest strictures can be dilated by endoscopic irrigation. Point strictures can be released by cutting the fibrous band with a hand drill through an endoscope (PolyDiagnost GmbH, Pfaffenhofen, Germany), after which the lumen springs open. Established strictures (both point and diffuse) can be stretched by intraluminal

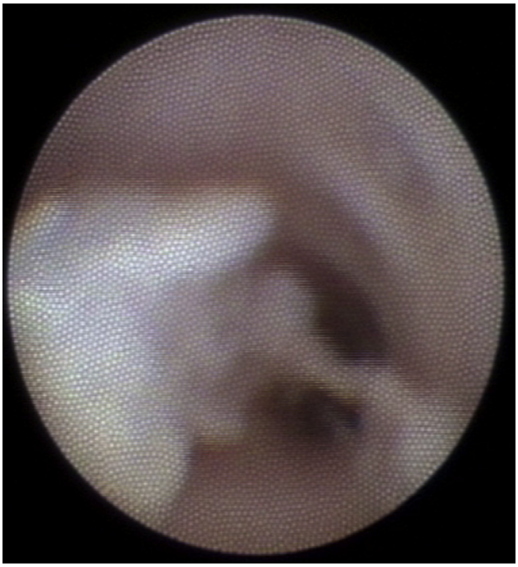

Fig. 3. Mucous plugs within the duct lumen.

balloon dilatation. Salivary balloon ductoplasty was first described in 1992 as a potential technique for the nonoperative elimination of benign salivary duct strictures.[2] It has since become the most widely reported technique; several case reports and small case series agree on the benefits of this technique for relieving salivary duct stenosis without the problems of surgical intervention, particularly in the parotid gland where these are most common.[3–6] This minimally invasive technique may be undertaken under radiological or endoscopic guidance and under local anesthesia. Radiological guidance requires a preoperative sialogram to localize the stricture, followed by insertion of the angioplasty balloon, using the fluoroscopic image to guide the balloon into the stricture before inflating it. A balloon slightly wider than the normal duct lumen is advised. A balloon with high inflation pressure or, alternatively, a cutting balloon, is advocated to release these dense fibrous strictures. Cutting balloons are a new technology and are constructed as conventional angioplasty balloon catheters, but with small microtome blades mounted along the length of the balloon itself. These blades are deployed as the balloon inflates, and are forced out into the vessel or duct wall to make minimal, superficial incisions across the surface of the band of stenotic tissue (**Fig. 4**). The cutting balloon is a 2-cm long, 3.5F, 90-cm overall catheter, with typical inflation diameter of 2.5 mm. These balloons have been used in vascular and nonvascular interventional radiology as a more conservative and controlled way of incising through circumferential occlusions, and they have been found to reduce damage to vessel walls, yet achieve more precise relief from stenosis.[7,8]

The technique is essentially the same when used with an endoscope, except that the balloon is positioned under direct vision, passed down the duct beside the endoscope, and forced forward through the stenosis. A postoperative sialogram is recommended to confirm successful elimination of the stricture (**Fig. 5**).

Technique for radiologically guided balloon sialoplasty

The number and location of strictures is identified on a preoperative sialogram. Digital subtraction sialography is helpful in eliminating large dense superimposed objects, such as teeth and restorations.[5] Local anesthesia may be obtained by infiltration along the anterior parotid duct and by per-ductal instillation of local anesthetic solution, such as 2% lidocaine. With radiographic contrast in situ in the duct and under fluoroscopic guidance, a 2-cm long angioplasty balloon, slightly wider than the desired duct diameter, is inserted over a hydrophilic guidewire that is passed along the main excretory duct. A parotid duct may be dilated with a balloon between 2.5 and 4 mm in diameter (when inflated), dependent on the degree of preexisting adjacent dilatation. The balloon catheter should ideally be on a reasonably rigid shaft to allow it to be pushed through tight proximal strictures, and it should reach pressures of at least 10 to 15

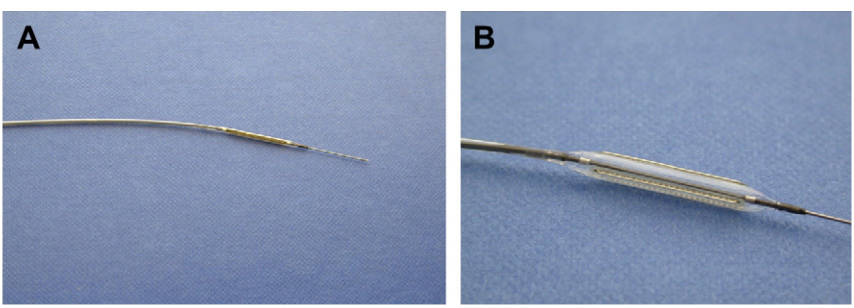

Fig. 4. (*A*) Cutting balloon catheter (deflated, as on insertion into the salivary duct). (*B*) Inflated cutting balloon showing microtome blades on the surface.

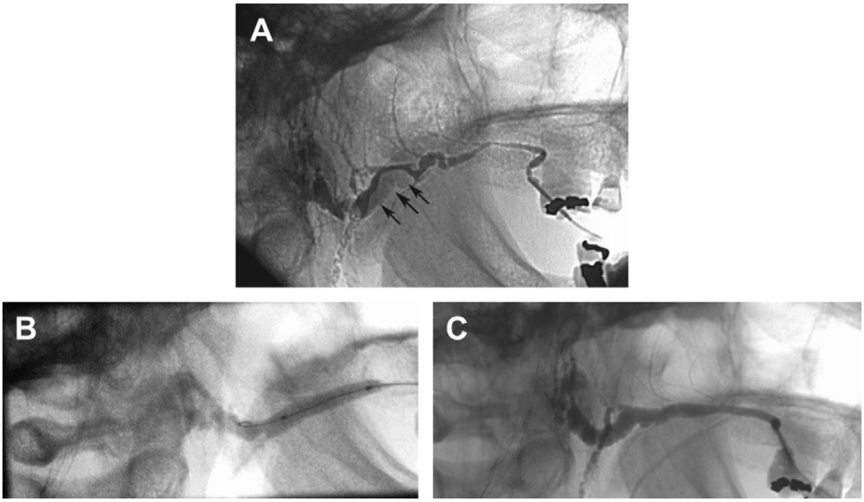

Fig. 5. Parotid ductoplasty; (*A*) Preoperative appearance showing a distally placed diffuse stricture with irregular dilation of the proximal duct, containing several mucous plug filling defects (*arrows*). (*B*) Balloon inflated within the stricture. (*C*) Postoperative sialogram showing elimination of stricture and dispersal of mucous plug debris.

atmospheres on inflation (eg, Symmetry Stiff Shaft Balloon, Boston Scientific Corporation, Natick, MA, USA). Once manipulated into position within the most proximal stricture, the balloon is inflated rapidly, held in place for 2 minutes, and deflated. The procedure can be repeated to eliminate all identifiable strictures, working stepwise distally toward the duct orifice. This technique has the advantage of minimal instrumentation. It involves only the insertion of a 3F angioplasty balloon catheter into the duct, and it is therefore a minimally invasive procedure. The position of the catheter can be monitored throughout the procedure by fluoroscopy. A dense point stenosis may be difficult to dilate fully, and on inflation, the balloon (which is filled with radiopaque contrast media, visible on the radiographic image) shows a "waist" where it is indented by the tight stenosis. The stricture should be dilated repeatedly until it is eliminated. Here, cutting balloons have an advantage.

Technique for endoscopically guided balloon sialoplasty

Preoperative sialography is strongly recommended, even for sialendoscopy, to identify the presence and position of all stenoses and help plan the depth required for insertion of the sialendoscope. As discussed earlier, local anesthesia can be delivered incrementally through the endoscope. The duct orifice is dilated manually until the endoscope can be inserted and advanced to the first stricture. The stricture may respond to pressure applied directly to it by the tip of the endoscope; otherwise, an angioplasty balloon, placed in parallel with the endoscope, can be advanced through the stricture and inflated under direct vision. However, the duct needs to be wide enough to accommodate the combined width of the instruments. The balloon is carefully positioned within the tightest part of the stricture and may be inflated several times. The endoscope is advanced stepwise, treating each stricture as it is encountered, and working proximally toward the hilum of the gland.[6] The process is thus the reverse of the radiologically guided technique.

OUTCOMES

Several studies have reported success in case series from 30 to 125 patients, most (75.3%) with parotid duct stenosis.[1,5,6,9,10] Balloon ductoplasty was found to be technically feasible in 87% to 95% cases of duct stenosis, and resulted in improvement or elimination of mealtime-related pain and swelling in 92% to 96% of cases. In a personal series of 249 salivary balloon ductoplasties, 230 have been undertaken in the parotid gland over a 10-year period, and 11% required bilateral parotid dilatations. On postoperative sialography, the stricture was judged to have been eliminated in 205 of 249 cases (82%); the stricture was shown to be partially eliminated in 33 (13%); and the procedure failed in 12 (5%). Follow-up is important in these cases as experience shows that stenosis can re-form over time. Sixteen patients have returned with re-stenosis of the salivary duct, which has required repeat balloon ductoplasty (mean interval, 31 months).

SALIVARY STONES

Problems and Aims of Treatment

Salivary stones commonly form in certain locations; treatment modalities are needed tailored to these presentations. The submandibular duct is notable for the marked curve or "genu" formed, as the duct passes over the posterior free margin of the mylohyoid muscle to descend into the gland. The parotid duct changes direction at 2 sites; it curves around the masseter muscle distally, and there is a right-angled bend proximally, as it descends into the deep aspect of the parotid. This is the point where the hilum and duct unite. Stones form in the hilum of the parotid and submandibular glands adjacent to these kinks. Clinically it seems that the anatomic shape of the duct system plays a part in stone formation (**Fig. 6**).

New Treatment Modalities

In the early 1990s, dedicated salivary lithotripters were developed (Minilith; Storz Medical AG, Tägerwilen, Switzerland). These lithotripters were modeled on the machines used in renal lithotripsy, but they were a miniaturized version with a small shockwave focus, ideal for use in the head and neck. Initially, they were deployed for all salivary stones, and it is based on this experience that current protocols have evolved.

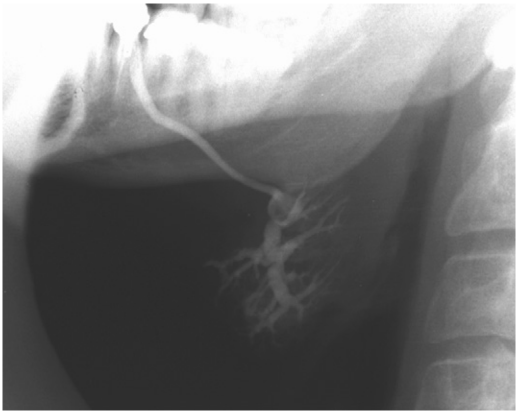

Fig. 6. Typical location for a submandibular duct stone lodged in the 'genu' region.

Salivary lithotripsy is simple to perform, requires no analgesia, and has low morbidity. Treatment of large stones is protracted (up to 15,000 shockwaves). Interventional sialographic or endoscopic techniques have been developed to compliment lithotripsy by offering solutions to the retention of small stone fragments and for the dilatation of duct strictures. The advent of sialoendoscopes produced new opportunities, but attempts at endoscope-guided intracorporeal laser and shockwave lithotripsy were not successful. The energy transferred was excessive and led to ductal damage and stricture formation. In contrast, simple endoscopic or radiologically guided basket retrieval of stones was effective and, to a lesser extent, microforceps proved effective at retrieving small stone fragments. A series of microinstruments in the form of tridents, graspers, and balloon catheters are now available for use with the endoscopes. It is with this selection of instruments that the protocol presented in **Table 1** has been adopted.

Interventional sialography and endoscopic therapy

Endoscopy and radiologically guided intervention are discussed together because the active agent (basket) is the same in each technique.

Endoscopes designed for salivary intervention range in size and faculty and are rigid or semirigid. Most endoscopic interventions are undertaken with a basket. Occasionally, a balloon is used, which can be inflated behind a stone to draw it forward to the duct ostium, as reported by Briffa and Callum[11] in the first radiologically guided extraction of a stone. Dormia baskets should be in the range of 2 to 3F gauge, with 3- to 12-wire designs, and may be tipped or tipless. Nitinol tipless baskets have great flexibility, can be opened and forced forward over impacted stones, but are not particularly radiopaque. Steel baskets have more rigidity and are easily identified on radiological images.

Pre-interventional assessment is by ultrasound or sialogram, to confirm the size (ideally <5 mm) and mobility of the stone and ensure no distally placed strictures are present. Most clinicians have used small Dormia baskets with a high degree of success.[12–15] The radiological technique includes a preoperative sialogram to visualize the obstruction. Under radiographic guidance, using fluoroscopy as in a vascular radiology suite, the basket is advanced past the stone, opened, and then drawn forward. Usually, the stone can be secured by rotating the wire basket as it comes into contact with the calculus. This technique has the advantage of requiring little

Table 1
Protocol showing the optimal application of minimally invasive techniques for the elimination of stones

	Management Protocol for Salivary Stones
Mobile stones <5 mm	
SMG and parotid	Endoscopic/radiological basket removal
Fixed stones >5 mm	
SMG	(1) Intraoral endoscope-assisted surgery (2) Lithotripsy ± basket removal (often used if (1) medically contraindicated)
Parotid	(1) Lithotripsy (2) Endoscope assisted surgery

Abbreviation: SMG, submandibular gland.

Data from Iro H, Zenk J, Escudier MP, et al. Outcome of minimally invasive management of salivary calculi in 4,691 patients. Laryngoscope 2009;119(2):263–8.

additional equipment, because it uses facilities normally available within the radiology department of a general hospital (**Fig. 7**).

With the endoscope, this action is carried out under direct vision (**Fig. 8**). The parotid duct is easy to cannulate. Usually, the submandibular duct ostium has to be incised for insertion of an endoscope. Once the stone is grasped, it cannot easily be disengaged and released. This situation would cause a basket to become lodged in the duct. Hence, the stone size limits this technique (**Fig. 9**). Tight strictures and long narrow duct segments, lying distal to the stone and needing prior dilatation with a balloon catheter, can be managed, ideally, within this same procedure. Once the stone is brought to the ostium, a small incision is made to retrieve the calculus. Using appropriate selection criteria, the success of the technique is high; in the authors' experience of 223 radiologically guided stone extractions, 75% were made completely stone-free and a further 9.4% had 1 or more stones removed, although residual stones remained in unreachable sections of the duct system (**Table 2**).[10] Stones positioned within the hilum, within diverticula or small secondary branches are difficult to retrieve because the basket cannot be advanced behind or around the stone to engage it.

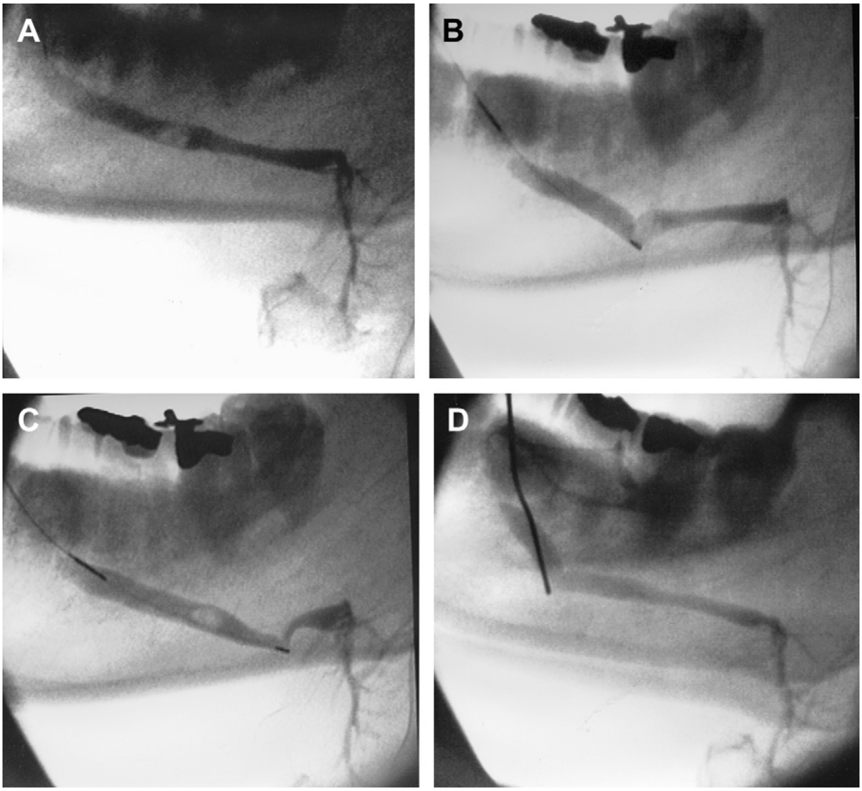

Fig. 7. Fluoroscopic sialogram images showing stages of radiologically guided stone removal. (*A*) Stone is identified as a filling defect within the mid one-third of the submandibular duct. (*B*) A closed Dormia basket is inserted up to the stone. (*C*) The basket is pushed beyond the stone, before opening the basket and drawing back to capture the stone. (*D*) The postoperative sialogram confirms that the stone has been removed and no further stones can be identified.

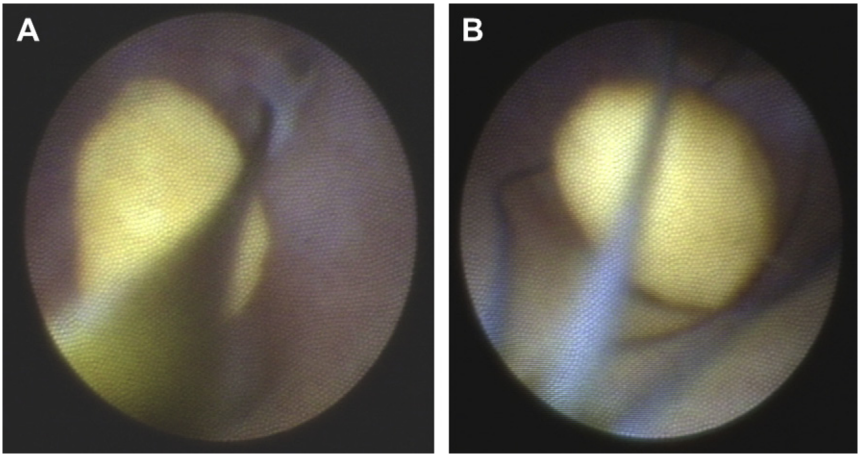

Fig. 8. Basket retrieval of stone under endoscopic control; (*A*) the stone is bypassed by the closed Dormia basket; (*B*) the basket is opened and withdrawn over the stone to capture it.

Morbidity

Complications The principal side effects are discomfort and swelling of the affected gland, and antibiotics are prescribed after extensive manipulation, to reduce the risk of infection. In one case, the basket became impacted and required surgical release from the parotid duct. In 2 further basket impactions, the duct was successfully dilated by angioplasty balloon insertion alongside the basket, which freed the impacted basket and stone. These experiences highlight the need for sound preparatory imaging to determine the size, location, and mobility of the stone.

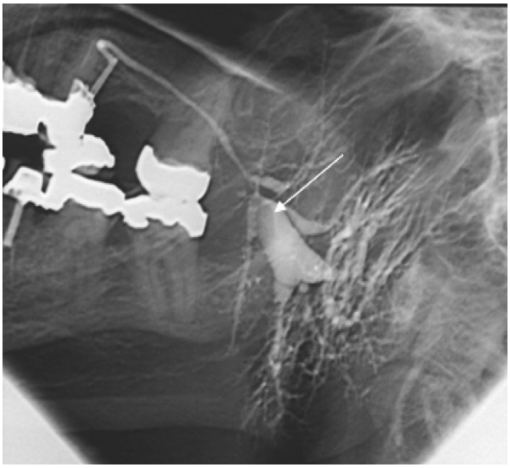

Fig. 9. Parotid sialogram showing a large stone (*arrow*) within the dilated hilum of the parotid gland but lying proximal to a dense stenosis. This stone would not be suitable for basket extraction, being too large to pass down the duct and would risk impaction of basket and stone within the duct. Prior balloon ductoplasty should be performed.

Table 2
The selection criteria for radiologically or endoscopically guided stone extraction

Submandibular Gland	Parotid Gland
Mobile stone	Mobile stone
Stone diameter no more than 25% > distal duct caliber (distally placed stenosis requires prior dilatation)	Stone diameter no more than 25% > distal duct caliber (distally placed stenosis requires prior dilatation)
Patent main duct	Patent main duct
Stone within lumen of main duct distal to mylohyoid bend	Stone within main duct distal to hilum

Summary of Salivary Stones

Basket and forceps retrieval of stones can be performed under endoscopic or radiological control. Using appropriate selection criteria, stone clearance rates are excellent (over 75%).[10,16] Morbidity of the procedure is minimal but local infiltration is advised. A minor surgical procedure may be necessary to gain endoscopic access to the submandibular gland, but not with the radiologically guided technique.

GLAND-PRESERVING SURGERY

Stones in the Submandibular Gland

The previous techniques deal with stones that are small and mobile. A significant number of submandibular stones are larger than 8 mm in diameter and are usually located in the hilum of the submandibular gland. Experience has demonstrated that these stone are not amenable to lithotripsy or basket retrieval.

Technique

Two gland preserving techniques have evolved.[17,18] Both are designed to be used under day-case general anesthesia or, in appropriate patients, under local anesthesia. The object is to remove the stone via an intraoral procedure and to preserve the salivary gland (**Fig. 10**). One technique entails opening the duct along its length until the stone is visible within the hilum of the gland. The stone is then delivered and the duct marsupialized to the floor of the mouth. This approach has the benefit of allowing traction to be applied to the duct, and by doing so, advancing the stone and hilum of the submandibular gland by approximately 1 cm. An alternative approach maintains the integrity of the duct. The floor of the mouth is opened and the duct traced posteriorly until the calculus is identified. The duct is incised only over the surface of the stone. The stone is released and the continuity of the duct restored with a 6.0 Vicryl suture (Prolene suture material should be avoided, because it facilitates calculus formation).

Selection criteria

The assessment is by ultrasound or sialogram, but the presence of a palpable stone is an important predictor of stone retrieval. Nonpalpable stones are situated within the gland and are difficult to remove. The endoscope is used to confirm complete clearance after surgery.

Success rates

The results of 11 studies, relating to the removal of 1058 transoral calculi, report overall success in 92.1% of cases.[19]

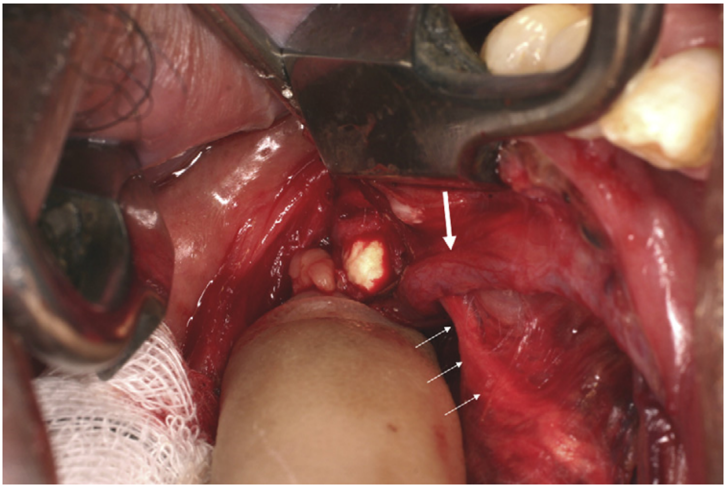

Fig. 10. Intraoral surgical removal of stone from hilum of the submandibular gland. The stone is seen through the incision made in the duct. Note the submandibular duct (*arrow*) and lingual nerve (*small arrows*).

Morbidity

Surgical exploration of the floor of the mouth leads to significant discomfort for 48 hours. The risk of injury to the lingual nerve is reported as 0.5%, but it is usually due to stretching and resolves over a 10-day period. Postoperative hemorrhage is uncommon. Reports of duct stenosis vary from no cases to 4.3% of cases. If the sublingual gland is violated, there is a risk of ranula (4%–7%); so at surgery, the sublingual gland is usually rotated out of the surgical field.[18]

Stones in the Parotid Gland

Patients have an understandable reluctance to submit to parotidectomy as the first-line treatment for a parotid stone. The high success rate of minimally invasive techniques (lithotripsy or basket retrieval) means that only 10% of cases remain symptomatic, and they are ideally suited to endoscope-assisted surgical removal of the stone. Selection criteria include large stones (>1 cm), glands with persistent sialoadenitis that are unsuitable for lithotripsy, and recalcitrant stones. The technique has been described previously (**Fig. 11**).[19] An endoscope is inserted into the duct, the stone visualized, and its position marked on the surface of the skin. The light emanating from the end of the endoscope is visible through the soft tissues. If the stone is large and superficial (anterior border of masseter), then it can be approached through a vertical incision directly over the stone. This approach is not suitable for proximal stones within the gland. In such circumstances, a limited preauricular incision is made under general anesthesia, the skin is elevated, and the endoscope tip light is used to identify and skeletonize the duct. The stone is then released by a longitudinal duct incision. The duct walls are reapposed and the tissues closed in layers. A pressure dressing reduces the risk of sialocele.

Success

Stone retrieval rates are greater than 95%. If the stone cannot be visualized preoperatively (endoscopically), then it is prudent to delay the operation for further assessment.

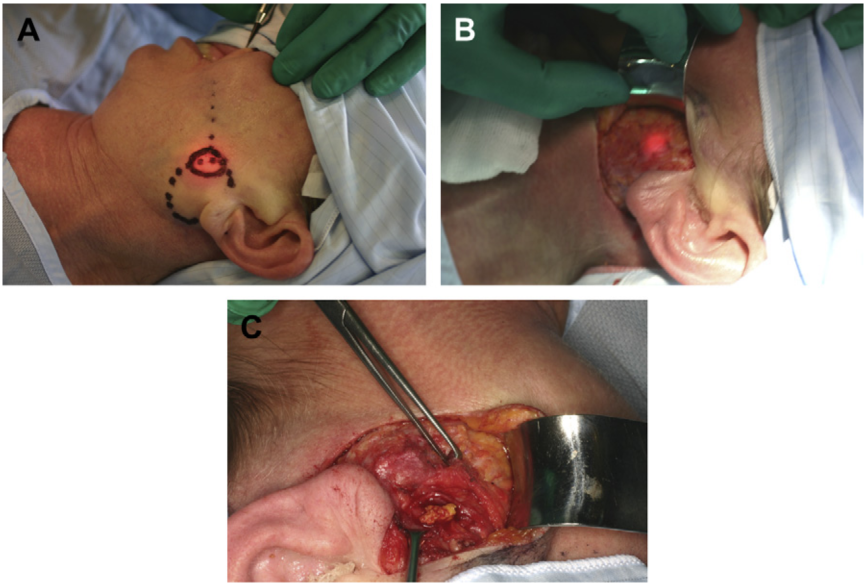

Fig. 11. (*A*) First stage in surgical endoscope-assisted stone removal from parotid gland, with the bright endoscope tip aligned against the parotid stone. (*B*) Endoscope-localized guidance of surgical approach onto parotid stone. (*C*) Identification and retrieval of stone.

Morbidity

Endoscope-assisted stone retrieval is much less invasive than the traditional superficial parotidectomy, with a significantly reduced threat to the facial nerve. In a series of over 60 cases, facial nerve injury was not encountered; however, this procedure is invasive and requires a general anesthetic. Patients are discharged and sent home on the day after surgery. In a consecutive series of 36 cases, 1 patient developed acute sialoadenitis in the immediate postoperative period and 1 patient developed a troublesome stricture that required duct ligation. In 2 further cases the duct was damaged and ligated. There were no long-term sequelae at follow-up after 3 years.

SUMMARY

Over a period of 20 years, the management of salivary obstruction has changed dramatically. The accumulating data suggest that the current standard of practice, which is gland resection, will not be tenable in the future. It is envisaged that, with time, small salivary gland centers will develop to serve populations of about 1 million. In a series of 4600 salivary calculi, stone clearance was 80%, with gland removal of only 3%.[16]

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