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RESEARCH PAPER

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Intraoral microscopic-assisted sialolithotomy for management of medium-large submandibular sialolithiasis: A refined technique

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Abstract

Objectives: Sialendoscopy has become the standard treatment for sialolithiasis; however, larger submandibular calculi may require an incisional technique. This study describes and evaluates an intraoral microscopic-assisted sialolithotomy (IMAS) as a refined submandibular stone extraction technique.

Methods: Retrospective case series of 64 submandibular IMAS procedures operated at a tertiary university center and private hospital from 2015 to 2021 were evaluated. Preoperative radiological assessment included noncontrast computed tomography scan ± magnetic resonance sialography. Stone characteristics (side, number, size, and location), operative findings, complications, and postoperative follow-up were reviewed. Success was defined as successful intraoral stone extraction with no symptoms or stone recurrence for at least 12 months postoperatively.

Results: The study included 43 males and 19 females, mean age 38 ± 12 years. Two patients had bilateral stones. All but one operated gland had stones extracted (98.4%), however the true success was 93.8% (60/64) as three patients had recurrent/residual stones within a year. Biggest stone longest diameter was 9.8 ± 4.6 mm (range, 5–30 mm). Hilar and intraglandular stone locations were 73.4% and 6.3%, respectively. Median operative time was 55 min. Adjunctive sialendoscopy was performed in 42.2%. Its use is significantly correlated with having >3 stones (mean 3.4 vs. 1.2 stones) [$P < 0.001$, 95% confidence interval: −3.19 to −1.25]. Minor complications included temporary lingual paresthesia (7.8%) and postoperative ranula (1.6%).

Conclusions: Submandibular IMAS is a highly effective safe technique for stones (≥5 mm). The improved microscopic visualization, illumination and magnification allows addressing all stone locations including intraglandular calculi and enables better lingual nerve identification and preservation.

KEYWORDS
microscopic-assisted surgery, sialolithiasis, submandibular stones, transoral sialolithotomy

Key points

- The intraoral microscopic-assisted sialolithotomy technique described was found to be a highly effective and safe submandibular gland-preserving approach for medium-sized to large (≥5 mm) submandibular sialolithiasis.
- Using the operating microscope with its enhanced visualization, illumination and magnification allows the surgeon to address all submandibular stone locations including deep hilar and even intraglandular calculi and to clearly identify and safeguard the lingual nerve.
- Having multiple (≥3) stones likely requires the need for a planned complementary second look sialendoscopy. Stones found intraoperatively to be friable may also benefit from adjunctive sialendoscopy, ensuring complete fragment extraction. Reserving endoscopy use for these indications significantly reduces operative time and thus potentially decreases surgical and anesthesia morbidity. It also preserves the use of these delicate expensive scopes for situations in which they would be most needed.

INTRODUCTION

Sialolithiasis (salivary calculi) is the most common salivary gland ductal pathology. Its incidence in the general population has been reported to be around 1%. Salivary stones are most often seen in the submandibular gland (80%–90%) as compared to the parotid (5%–20%).[1,2] Koch et al.[3] reported that 34% of sialoliths are found in the duct (ductal stones), 57% within the gland hilum (hilar stones), and 9% in gland parenchyma (intraparenchymal stones). Eighty-eight percent of salivary stones will be less than 10 mm (the majority being within 3–7 mm). In a small percentage of cases (7.6%), salivary stones will grow to sizes greater than 15 mm.[4,5]

The submandibular gland's high propensity for stone formation, compared to the parotid, may be attributed to its longer and wider caliber duct, through which alkaline saliva with high levels of mucin and calcium flows against gravity at a slower rate.[6] Regardless of where they form, salivary stones are primarily composed of calcium phosphate and grow at a rate of 1–1.5 mm per year.[7]

Traditionally, patients with symptomatic sialolithiasis undergo excision of the salivary glands. Gland preservation has been recommended after histopathological evaluation showed normal histologic findings in patients with submandibular gland resections for sialolithiasis.[8] In addition, salivary scintigraphy performed before and 6 months after stone removal has shown return of secretory function to normal levels.[9]

Stones in the distal duct are often palpable and can be easily retrieved via an intraoral sialolithotomy under local anesthesia. Large salivary gland stones, however, have always been a therapeutic challenge, mandating gland excision in many instances. Over the last two decades, minimally invasive salivary stone extraction techniques that allow for gland preservation have become available. The advent of sialendoscopy and lithotripsy techniques had reduced the prevalence of submandibulectomies as the default treatment modality for deeper, nonpalpable stones in the gland duct and hilum.[10,11]

Extracorporeal shock wave lithotripsy (ESWL) was introduced in early 1990s as a modality for treatment of sialolithiasis. It entails application of ultrasonic waves to fragment the stones from outside the body. Success rates range from 40% in the submandibular to 75% in the parotid glands, with specifically poor results in the case of large stones.[12] Marchal and Dulguerov proposed intracorporeal fragmentation before endoscopic extraction for large stones (>4 mm in diameter) for submandibular cases.[13] However, he observed that despite prior fragmentation with an intraductal laser and wire basket extraction, successful removal of larger stones was possible in only 80% of cases. He attributed 20% of failures to stones greater than 6 mm in diameter and the presence of stenotic salivary ducts. In a trial to overcome the somewhat higher failure rates of endoscopic stone retrieval, he reported a technique involving the use of combined sialendoscopy and a transoral open approach to such sialoliths, which is known as the combined approach (CA).[14]

More recently, "Robot-assisted sialolithotomy" has become more popular in certain centers. This entails extraction of submandibular stones residing in the floor of the mouth using the DaVinci Surgical System via a transoral approach. Proponents of using the robot for this indication highlighted its superior advantage as regards field magnification and lingual nerve identification.[15,16] However, the robot is not a feasible surgical modality in many regions in the world. Similarly, sialendoscopy and ESWL may not always be readily available due to the need for sub-specialization training and the high costs of preparation and equipment maintenance.

Although the idea of transoral sialolithotomy for submandibular sialolithiasis management is obviously not new, herein we present our novel experience in using the operating microscope to assist in intraoral stone extraction in a series of patients with medium-sized to large submandibular sialolithiasis with or without sialendoscopy. We describe and evaluate our refined microscopic technique as a gland preserving minimally invasive option, which to the best of our knowledge, has not been published before.

MATERIALS AND METHODS

Study design and patients

This study was conducted as a retrospective chart review of 62 consecutive patients who received an intraoral microscopic-assisted sialolithotomy (IMAS) technique for managing medium-sized to large (≥5 mm) submandibular stones as apparent by preoperative imaging including noncontrast computed tomography (CT) scan ± magnetic resonance (MR) sialography (as per our institutional radiology protocol for sialolithiasis). Two patients had bilateral disease; accordingly, 64 procedures were performed. Patients were operated on at a tertiary university hospital and a private hospital over a 6-years period from April 2015 to June 2021 by a senior primary surgeon with more than 10 years sialendoscopy experience.

The patients' medical records were reviewed for patient demographics, stone characteristics (side, number, size, and location), operative findings, hospital stay, postoperative follow-up, and complications. The study protocol was approved by our institutional ethics committee review board and individual patient consent was waived due to the retrospective nature of the study.

To simplify radiological localization of stones, we divided the submandibular duct into three equal thirds; proximal third close to gland hilum, distal third close to duct papilla, and middle third in between (midductal). Proximal stone locations included hilar and immediate prehilar locations. Intraglandular stone location was defined as any stone located proximal to the gland hilum within secondary or tertiary branches; sometimes referred to as “intraparenchymal” stones.

Procedural success was defined as successful intraoral stone extraction with gland preservation. However, true success was defined as successful stone extraction with no recurrence of symptoms or recurrent stones (confirmed by ultrasound) for at least 12 months postoperatively.

Surgical technique

All patients were operated in absence of acute inflammatory episodes under general anesthesia with naso-tracheal intubation. The mouth is opened using a teeth block fitted contralateral to the stone side and a malleable self-retaining cheek retractor applied to improve intraoral accessibility (Figure 1A). An assistant retracts the tongue away by using a large Davis-Boyle retractor blade to allow posterior floor of the mouth access. The stone is palpated transorally to provide the surgeon with a mental 3D sense of its approximate location. Pushing the submandibular gland superiorly by an assistant applying external digital pressure below the patient's mandible further helps in stone localization (Figure 1B).

Using the operating microscope, the operative site is infiltrated by 1:100,000 epinephrine solution to provide local decongestion. A 1–2 cm incision is performed in the posterior floor of mouth parallel to the inner mandible using a Colorado needle tip monopolar cautery (Stryker Corporation) (Figure 1C). Blunt dissection is performed gently under microscopic control, identifying the lingual nerve. Utmost care is taken during this step to avoid nerve injury and to create a safe corridor to the submandibular duct. The stone is intermittently palpated to ensure maintaining a correct plane of dissection. Using a small self-retaining wound spreader retractor (KLS Martin GmbH & Co.) at this stage can maintain better exposure of the surgical field. A 15-blade scalpel is used to make a linear incision in the duct parallel to its axis at the area of stone location (or overlying the stone for intraparenchymal calculi) (Figure 1D). Following stone extraction, saline irrigation of the wound complemented by gland massage is done to flush out any mucus, debris, or residual stone fragments. Finally, the wound is approximated by using one or two loose 4-0 Vicryl sutures allowing a route for drainage rather than performing a formal sialodochoplasty (Figure 1E).

In multiple sialolithiasis cases, the above described intraoral sialolithotomy technique is preceded by performing a diagnostic sialendoscopy where the Wharton's duct papilla orifice is dilated using salivary duct dilators (Karl Storz Co. GmbH) followed by the introduction of a 1.3/1.6 mm Marchal semirigid all-in-one miniature endoscope (Karl Storz Co., GmbH). This facilitates implementing a second look sialendoscopy procedure after the stones are extracted to ensure that none are left behind.

Finally, extracted stone(s) is/are photographed beside a measuring ruler for shape and size documentation for correlation with preoperative imaging data (Figure 2).

Postoperative care and follow-up

All patients received prophylactic broad-spectrum antibiotics due to the nature of the underlying potentially septic chronic inflammatory disease. Patients were discharged the same day following surgery and instructed to avoid saliva-stimulating food in the first 3–4 weeks.

Patients were seen 7–10 days postoperatively during which intraoral stitches were removed and any postoperative complications were checked for. All patients were followed-up for a period of at least 12 months for persistence or recurrence of symptoms, examining for the presence of a clear salivary flow from the papilla on gland massage as well as reporting any delayed complications. Ultrasonography was used to ascertain the absence of any residual or recurrent sialolithiasis.

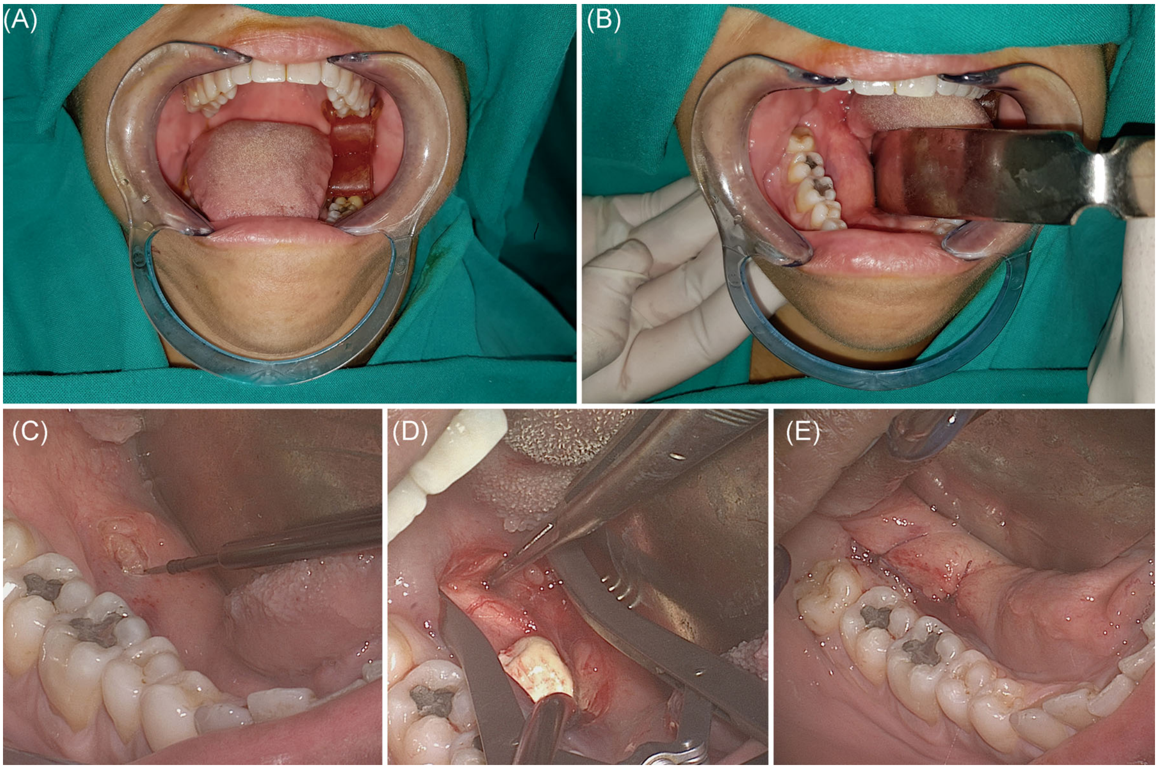

FIGURE 1 Intraoral microscopic-assisted sialolithotomy operative technique. (A) Oral exposure using contralateral teeth block and malleable self-retaining cheek retractor. (B) Posterior floor of mouth access attained by tongue retraction. (C) Incision using Colorado needle monopolar cautery at palpable stone site. (D) Microscopic stone extraction assisted by self-retaining spreader retractor safeguarding lingual nerve. (E) Wound approximation with two loose Vicryl stitches.

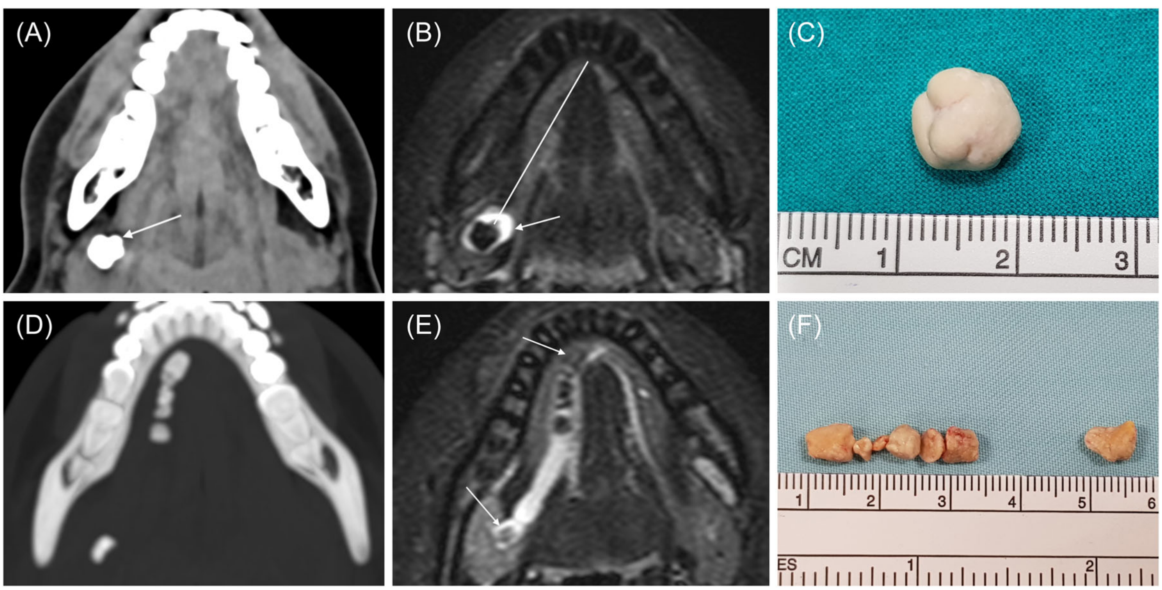

FIGURE 2 Correlation between pre-operative imaging and submandibular extracted stone(s), as marked. Non-contrast CT showing (A) single and (D) multiple radio-opaque submandibular stones. (B, E) MR sialography of same cases delineating ductal morphology. (C, F) Extracted stones measured against ruler for shape and size verification. CT, computed tomography; MR, magnetic resonance.

RESULTS

Our study included sixty-two patients with submandibular sialolithiasis, 43 (69.4%) males and 19 (30.6%) females with a mean age of 38 ± 12 years (range, 11–65 years). Two patients had bilateral stones. Thirty-eight glands (59.4%) had a single stone whereas 26 (40.6%) had multiple stones (range, 2–12, mean 3.5 ± 2.6). Only 1/64 operated glands failed stone extraction using the IMAS technique described, giving a procedural success rate of 98.4%. This patient had preoperatively a clinically nonpalpable stone and intraoperative microscopic stone localization was not attained (Table 1).

Thirty-seven out of 64 procedures were performed for the left side (57.8%) and 27 for the right (42.2%). The grand total number of stones extracted was 132 stones with varying sizes and shapes. The mean longest diameter of the biggest stone extracted in each case was 9.8 ± 4.6 mm (range, 5–30 mm) and that of all stones extracted was 6.8 ± 4.5 mm (range, 1.5–30 mm).

Preoperative imaging "confirmed by intraoperative findings" showed that 87/132 stones (65.9%) were proximal (hilar) in location, 15 (11.4%) midductal, 16 (12.1%) distal and 14 (10.6%) intraglandular. Forty-seven of the 64 submandibular glands (73.4%) had their biggest stone located in hilar position, while 8 (12.5%), 5 (7.8%), and 4 (6.3%) were in midductal, distal, and intraglandular locations respectively.

The adjunctive use of sialendoscopy for a second look examination was performed in only 27/64 glands (42.2%). The total median operative time was 55 min (range, 10–206 min). The mean operative time of cases that underwent the microscopic technique alone was 37.7 ± 20.3 min compared to 95.2 ± 41.6 min when performing the microscopic technique with second look sialendoscopy. This was found to be statistically significant ($P = 0.04$). Correlating the use of second look sialendoscopy with multiple variables (including age, stone size, number, and location) was done using bivariate analysis and independent sample *t*-test. This revealed that multiple stones were the only statistically significant justification for its use (mean 3.4 stones compared to 1.2 stones for microscopic technique alone) [$P < 0.001$, 95% confidence interval: −3.19 to −1.25]. Patients were followed-up for a period ranging from 12 to 52 (median 20) months.

Three patients got residual/recurrent stones postoperatively on the same side within the first year after surgery. Therefore, the true success rate was 93.8% (60/64). The first patient developed a recurrent hilar stone (3 mm) 12 months after the procedure whereas the primary stone location was intraglandular; of note this patient had Sjogren's syndrome with additional multiple parotid calcifications. The second patient got a recurrent 1.7 mm left hilar stone 11 months postoperatively. The third patient had a residual nonsymptomatic right intraglandular stone (5.9 mm × 4.1 mm) discovered 3 months following surgery; this patient had multiple tiny stones (more than 10) extracted from the same side. None of our patients including the patient that failed stone extraction were symptomatic enough to justify gland excision giving our study 100.0% gland preservation rate.

TABLE 1 Submandibular IMAS case series data.

Demographic data		
Number of patients	62	
Age (years)	Range, 11–65 (mean ± SD, 38 ± 12)	
Sex [*n* (%)]	43 males (69.4%)	19 females (30.6%)
Laterality	60 unilateral	2 bilateral
Total number of procedures	64	
Stone data		
Side [*n* (%)]	27 right (42.2%)	37 left (57.8%)
Number [*n* (%)]	38 single (59.4%)	26 multiple (40.6%)
Longest dimension (mm)[a]	Range, 5–30 (mean ± SD, 9.8 ± 4.6)	
Location[a] [*n* (%)]		
Distal	5 (7.8%)	
Midductal	8 (12.5%)	
Proximal	47 (73.4%)	
Intraglandular	4 (6.3%)	
Operative data		
Second look sialendoscopy [*n* (%)]	27 (42.2%)	
Operative time (OT, min)		
Median total OT	55 (Range, 10–206)	
Mean OT microscopic only	mean ± SD, 37.7 ± 20.3	
Mean OT microscopic + sialendoscopy	mean ± SD, 95.2 ± 41.6	
Success rates [*n* (%)]		
Stone extraction	63/64 (98.4%)	
True success	60/64 (93.8%)	
Gland preservation	64/64 (100.0%)	
Complications [*n* (%)]		
Failed extraction	1/64 (1.6%)	
Residual/recurrent stone	3/64 (4.7%)	
Temporary lingual paresthesia	5/64 (7.8%)	
Ranula	1/64 (1.6%)	

Abbreviation: IMAS, intraoral microscopic-assisted sialolithotomy.
[a]Of the biggest stone.

Minor complications included temporary lingual paresthesia and ranula. Five patients (7.8%) developed temporary tongue paresthesia postoperatively. This lingual nerve paresis completely resolved within 1–2 months postoperatively in all cases. Only one patient developed a small ranula 2 months postoperatively that emptied spontaneously, however, it developed again 6 months later but the patient refused any further surgical intervention. No major complications were encountered.

DISCUSSION

The management of large salivary calculi has always been a therapeutic challenge.[17] Sialadenectomy for submandibular stones was the traditional approach after failure of medical treatment. Typically, it involves resection of glandular tissue along with its associated duct. Failure to do so can result in complications associated with the presence of intraductal residual sialoliths, which may lead to recurrent infections or cutaneous/intraoral fistula formation due to sialolith migration.[18] Moreover, transcervical submandibular gland excision involves a risk of marginal facial nerve weakness (1%–8%), cervical scar formation and occasionally permanent lingual nerve paresis (1.6%).[19–21]

After introducing sialendoscopy as a minimally invasive stone retrieval technique, a paradigm shift toward managing sialolithiasis occurred aiming for gland preservation. Nevertheless, sialendoscopy alone might not be enough to manage larger stones. Lithotripsy techniques via endoscopic laser fragmentation or pneumatic stonebreaker system have been proposed.[22,23] These can be good options for intermediate-sized sialoliths (4–6 mm). However, in larger stones, lithotripsy often necessitate extremely long operative times and may be hazardous as generated thermal or mechanical damage could lead to future ductal stenosis. ESWL with sialendoscopy stone fragment extraction is another option more popular in Europe. However, multiple sessions are often required and there is a potential for surrounding tissue damage and missed stone fragments within the duct with a high possibility of recurrence.[24] Intraductal and extracorporeal lithotripsy techniques are time-consuming and require expensive devices, which explains why these techniques are not so widely used worldwide.[25]

Marchal[14] originally described the combined approach for large posteriorly located submandibular calculi. They proposed using the endoscope for stone localization then incised the floor of mouth for stone extraction and repaired the duct using 5-0 Vicryl after stenting. In this initial report, CA was successful in stone retrieval in 20/29 cases with symptomatic success of 69%. However, further gland excision was required in 8/29 cases (27.6%). This high failure rate might have been partly attributed to inaccessibility and poor visualization of deeply seated calculi. Several articles have described reserving the CA for large submandibular stones > 7 mm in their longest diameter with success rates varying from 79.1% to 88%.[11,26,27]

The Erlangen group in Germany (2017) described a nonendoscopic transoral submandibulotomy technique for deep hilar stones in which the Wharton's duct is dissected from just behind the papilla till the gland hilum and incised over the stone then marsupialized. No stents were implanted and the marsupialized duct acted as a neo-ostium. Small deep inaccessible intraparenchymal stones were left in situ, and spontaneous washing out was expected. Complete stone removal was achieved in 185/234 patients (79.1%) with first surgical intervention and gland excision required in 3.4% of the follow-up group (6/175).[26]

Fabie et al.[11] recently conducted a study on 206 patients with submandibular, parotid, and sublingual sialolithiasis. They compared their reliance on interventional sialendoscopy versus incisional sialolithotomy techniques and found that in the submandibular group, interventional sialendoscopy was successful only in 19/144 (13.2%) whereas intraoral incisional sialolithotomy was needed in 108/144 (75%) and submandibular gland excision was required in 17/144 (11.8%). They concluded that sialendoscopy alone is often incapable of removing larger (≥6 mm) submandibular stones and proposed gland-preserving incisional techniques without sialendoscopy for larger fixed palpable stones.

In comparison to the previous techniques, we feel that performing sialolithotomy under microscopic control provides superiorly illuminated visualization, better magnification, and even documentation of this narrow operative field. Enhanced identification of important structures provides safe dissection in the floor of the mouth and thus helps in functional lingual nerve preservation, which is reflected by our low complication rate. The microscope enabled us to successfully deal with deeply seated hilar or intraglandular stones constituting about 80% of our cases. The better visualization offered allows performing smaller targeted incisions obviating the need for duct or wound marsupialization. In our study, unlike the original CA technique described by Marchal,[14] we did not stent any of our patients. We believe that targeting the already dilated duct or gland hilum with a linear incision and loosely closing the resultant wound decreases the risk of ductal stenosis. Anatomical considerations such as large tongue, deep floor of mouth or small oral orifice were overcome by retraction maneuvers described earlier in the surgical technique and thus did not hinder the unified microscopic line of sight of both the surgeon and his assistants. All these advantages might not be attainable by using routine magnified visualization with operative loupes.

An integral component of the described CAs for large submandibular calculi is the use of sialendoscopy for stone localization. In our early experience, we often used the sialendoscope at the start of surgery to localize the stones, particularly the medium-sized ones. However, in later cases, we limited the use of sialendoscopy, for a "second look" procedure, in multiple stone cases or for intraoperatively friable fragmented stones. This attitude was backed by the high-quality preoperative imaging offered by the combined noncontrast CT/MR sialography and again the high magnification offered by the microscope. We found that performing sialendoscopy in these cases significantly prolongs the operative time. Another advantage would be "scope preservation" given the delicate nature and expense of sialendoscopes. Thus, scopes can efficiently be reserved for cases most likely to benefit from their use.

As an adjunctive tool for sialendoscopes, Walvekar et al.[15] described the use of the robot for a large hilar submandibular gland stone. The robot-assisted sialolithotomy technique was fully described in 2016 by Razavi et al.[16] While the recent robot-assisted technique is limited to only hilar stones, we found the use of the operating microscope helpful for locations other than the hilar position. The robot provides highly dynamic maneuverability inside the oral cavity with improved surgeon posture. However, the loss of the intraoperative tactile feedback of the stone is a major drawback. Moreover, the relatively high cost and unavailability makes the use of the robot for such cases unfeasible in many areas around the world.

A disadvantage we found in using the IMAS technique is the discomfort and back pain incurred by the surgeon from prolonged standing throughout the procedure. However, in our recent experience, operating with the microscope while sitting was attainable, providing more comfort to the surgeon.

CONCLUSION

The IMAS technique is a highly effective and safe submandibular gland-preserving approach for medium-sized to large (≥5 mm) submandibular salivary stones. The improved visualization, illumination and magnification offered by the operating microscope allows the surgeon to address all submandibular stone locations including intraglandular calculi and to clearly identify and safeguard the lingual nerve. Having multiple (≥3) stones likely requires the need for a second look sialendoscopy. Reserving the use of sialendoscopy for this indication significantly reduces the operative time, thus potentially decreasing surgical and anesthesia morbidity as well as conserving the use of these delicate expensive endoscopes for cases most likely to benefit from their use.

AUTHOR CONTRIBUTIONS

Principal investigator and senior author, revising the whole manuscript scientific writing, design, and figure selection: Emad A. Magdy. *Scientific writing and data analysis*: Mahmoud Seif-Elnasr. *Methodology section, radiological localization*: Omneya Gamaleldin. *Writing revision and figure formatting*: Mohamed K. Taha. *Writing revision and reference styling*: Mohamed F. Fathalla.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

ETHICS STATEMENT

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This research involved only patient charts. Institutional permission was approved for the study before submission for publication. Individual patient consent was waived due to the retrospective nature of the study.

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