Premiere Publications from The Triological Society

Read all three of our prestigious publications, each offering high-quality content to keep you informed with the latest developments in the field.

**Laryngoscope**

*Founded in 1896*

Editor-in-Chief: Samuel H. Selesnick, MD, FACS

The leading source for information in head and neck disorders.

[Laryngoscope.com](http://Laryngoscope.com)

**Investigative Otolaryngology**

Editor-in-Chief: D. Bradley Welling, MD, PhD, FACS

Rapid dissemination of the science and practice of otolaryngology-head and neck surgery.

[InvestigativeOto.com](http://InvestigativeOto.com)

**ENTtoday**

A publication of the Triological Society

Editor-in-Chief: Alexander Chiu, MD

Must-have timely information that Otolaryngologist-head and neck surgeons can use in daily practice.

[Enttoday.org](http://Enttoday.org)

WILEY
Sonolocation During Submandibular Sialolithotomy

Nahir J. Romero, MD; Andrew Fuson, MD; Christopher R. Kieliszak, DO; Arjun S. Joshi, MD

Objectives/Hypothesis: Ultrasound is a proven tool for diagnostic and therapeutic purposes for treatment of salivary gland pathology. It is also useful for localization of calculi during submandibular gland transoral sialolithotomy when calculi cannot easily be palpated. Our objective was to determine the efficacy of sialolith localization using ultrasound during submandibular gland sialolithotomy.

Study Design: Retrospective case series.

Methods: A study performed utilizing data compiled from 2009 through 2016 in a tertiary academic center. Treatment was completed in 164 patients with sialadenitis and sialolithiasis by submandibular gland transoral sialolithotomy in either the office (81%) or the operating room (19%). Ultrasound was used for localization of sialoliths during submandibular gland sialolithotomy. Main treatment outcomes studied were success of the procedure, complications, and follow-up.

Results: Successful sialolithotomy was performed in (147 patients) 90% of cases. Complications were minimal and included stricture formation, which occurred in 3% (five patients) of cases, followed by ranula formation in 1.8% (three patients) of cases. There were no incidences of lingual nerve injury.

Conclusions: Ultrasound can be used effectively for precise sialolith localization intraoperatively.

Key Words: Sonolocation, sialolithiasis, treatment, sialolithotomy, salivary glands, submandibular gland, calculi.

Level of Evidence: 4

INTRODUCTION

Sialolithiasis is one of the most commonly diagnosed salivary gland diseases1 and a major cause of head and neck swelling. Most commonly occurring in the submandibular gland (SMG),2 patients usually present with oral discomfort and episodic swelling and fullness peri-and postprandially during times of salivary gland stimulation.3 Obstructive salivary gland pathologies may contribute to acute or chronic sialadenitis.4 Surgical removal of the stones is often necessary due to recurrent symptoms.

In recent years, surgical treatment of submandibular salivary gland calculi has shifted away from traditional sialadenectomy toward gland-preserving techniques.4 The localization of stones is an essential step in the diagnosis and treatment of sialolithiasis and can be achieved by several different means. Localization during transoral submandibular sialolithotomy is traditionally performed by direct palpation of the floor of the mouth. However, the fibrous consistency of ductal strictures or previous focal scarring of the submandibular or sublingual gland may resemble sialoliths, leading to failed transoral exploration.5 Static imaging with computed tomography (CT) and magnetic resonance imaging (MRI) is undoubtedly useful in the diagnosis of calculi, but much less so during transoral sialolithotomy when smaller mobile stones tend to move along the ductal system. It is useful to have a real-time method of localization in this situation.

Sialendoscopy has been well documented in the literature for its ability to help localize calculi as well as aid in removal but has some limitations as well. In situations where calculi are large or fixed, a combined approach (sialendoscopy and transoral sialolithotomy) can be performed. For stones, lodged in the secondary and tertiary ductal system and inaccessible to the sialendoscope, there are no endoscopic options.

Ultrasound has myriad uses in the head and neck. With a reported sensitivity at or above 90%,6 it is a proven diagnostic tool for sialolithiasis in the major salivary glands. Furthermore, ultrasound has been utilized as an adjunctive tool in various sialolith extraction techniques.7–9 Ultrasound confers benefits of portability, intraoperative accessibility, and cost-effectiveness. Despite the many advantages that ultrasound offers in the localization of submandibular sialoliths, it can be difficult to assess those that are located at the duct ostium, in the anterior floor of the mouth,2 or ones that are smaller than 2 mm.

We consider ultrasound to be the first-line method for diagnosis and have previously described a technique to improve the reliability of ultrasound for detection of stones.8 In this article, we purport that ultrasound cannot only aid in the diagnosis of sialoliths but also help to localize submandibular calculi in a noninvasive manner during transoral submandibular sialolithotomy, as an alternative to a combined approach using sialendoscopy.
This is particularly useful in the office setting where resources may be limited.

MATERIALS AND METHODS

All consecutive patients between 2009 and 2016 who presented to the clinic for evaluation of sialadenitis underwent ultrasound examination. Patients with calculi of any size diagnosed during the initial ultrasound evaluation were included for analysis. Stone location parameters within Wharton’s duct were identified as follows: 1) distal: from the papilla extending proximally to the main bulk of the sublingual gland, 2) middle: from the end of the sublingual gland to approximately 1 cm in front of the posterior edge of the mylohyoid muscle, and 3) proximal or perihilar: extended from approximately 1 cm anterior to 1 cm posterior to the proximal edge of the mylohyoid muscle. Patients who were diagnosed with ductal stenosis on ultrasound were excluded from this analysis and treated using sialendoscopy. Patients with mobile sialoliths as demonstrated on ultrasound were treated successfully with sialendoscopy in the majority of cases and excluded from this analysis. Patients with larger stones greater than 4 mm, or smaller stones that were not amenable to a pure sialendoscopic technique (e.g., fixed in the hilar region) were treated with ultrasound-guided transoral sialolithotomy, and included in this analysis.

Primary treatment outcomes studied were the success of the procedure, time to completion of procedure, complications, and follow-up. Each patient was evaluated postoperatively in the office follow-up 1 week after the procedure and at 3 months by a follow-up telephone call. The absence of symptoms was used as a surrogate for effective treatment.

Description of the Technique

Each patient was placed in a semirecumbent position, and his or her head was turned to the contralateral side. Ultrasound examination was initiated using a Terason T3000 ultrasound machine (Terason, Burlington, MA) equipped with a high-resolution 7.5- to 10-MHz real-time linear-array transducer. Presence or absence of a calculus was noted (Fig. 1). Sonolocation of the calculus was then performed as follows. The ultrasound transducer was placed over the SMG with the free nonscanning index finger placed intraorally. Both the gloved finger and transducer hand operated concurrently in opposite vectors to direct the tissues toward the transducer. Using both, the ultrasound transducer and manual palpation, stones were both visualized and palpated.

After sonlocating the calculus, a small Deaver or sweetheart retractor is utilized on the ipsilateral side to retract the tongue and expose the floor of the mouth. If performed in the office, the patient is asked to push up on the gland, and if in the operating room, an assistant performs this maneuver. Lidocaine with epinephrine is instilled in the submucosal plane after localization of the sialolith was performed using a combination of palpation and ultrasound. At that point, a number 15 scalpel blade is utilized to make a mucosal incision only (Fig. 3). Blunt dissection is performed with tenotomy scissors. The lingual nerve is identified positively and mobilized medially, if in the hilar region. Lateral and deep to the lingual nerve, the submandibular duct along with the calculus is identified (Fig. 4). Sonolocation with ultrasound is again performed with the gloved nonscanning finger placed in the intraoral wound to confirm the location of the stone. The gloved finger should be seen to be directly adjacent to the stone (Fig. 5).

A number 15 scalpel blade is then utilized to incise the submandibular duct in a parallel fashion after confirming the location of the calculus by both palpation and ultrasound, with the lingual nerve under control. The calculus is then positively delivered. A repeat ultrasound and sonopalpation is then performed to confirm no retained stones are present.

RESULTS

A total of 164 patients underwent ultrasound-guided sialolithotomy either under local anesthesia in the clinic (132, 81%) or in the operating room (32, 19%). Within this population, 75 (46.0%) were men and 89 (54.0%) were female. The stone was successfully delivered in 147 (90%) cases; 119 were performed in the office (81%), and 28 were performed in the operating room (19%). The most..
common symptom that the patients experienced was general swelling (160, 97.6%), followed by post-/periprandial swelling (126, 76.8%) and pain (122, 74.4%) (Tables I and II).

After analysis, it was found that success is significantly associated with the location of the sialolith. In our patients, 100 sialoliths were located proximally close to the hilum, and 64 were located distally. Stones located distally had a 98.4% success rate, whereas proximal stone location had an 87.3% success rate ($\chi^2 P = .013$). Only one distal stone was not successfully delivered due to the inability of successful cannulation of the duct. Regarding stone size, the mean stone size among our patients was $7.5 \pm 4.1$ mm in successful cases and $11.8 \pm 8.5$ mm in nonsuccessful cases. The mean natural log of the stone size was $1.8 \pm 0.6$ in successful cases versus $2.3 \pm 0.6$ in unsuccessful cases ($P = .017$). The average size of the stones removed in our patients was 7.5 mm (range, 1–30 mm).

Time to completion of the procedure was tabulated. Successful stone delivery occurred on an average of 20.2 ± 8 minutes. On the other hand, failed procedures took an average of 37.7 ± 10 minutes. Long-term follow-up has been promising, with 147 patients (90%) being symptom free at 3 months (Table III).

<table>
<thead>
<tr>
<th>TABLE I. Surgical Outcome and Demographic Data.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome, no (%)</td>
</tr>
<tr>
<td>Successful</td>
</tr>
<tr>
<td>Failed</td>
</tr>
<tr>
<td>Demographics</td>
</tr>
<tr>
<td>Age, yr, mean (SD)</td>
</tr>
<tr>
<td>Gender, no (%)</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Gland, no (%)</td>
</tr>
<tr>
<td>Right</td>
</tr>
<tr>
<td>Left</td>
</tr>
</tbody>
</table>

SD = standard deviation.
Eight patients had complications during or after successful stone delivery. Five (3%) patients had strictured formation, and three (1.8%) patients had ranula formation. In the unsuccessful cases, there were five complications. Two of them were severe bleeding (1.22%), which required the procedure to be aborted. Three patients (1.83%) experienced severe pain under local anesthesia causing the procedure to be aborted. There were no cases of tongue numbness (lingual nerve injury) or motor dysfunction (hypoglossal injury) (Table IV).

**DISCUSSION**

Efficient localization of sialoliths is of paramount importance to surgical removal. Current techniques for localization include palpation, endoscopy, ultrasound, fluoroscopy, and static imaging such as CT and MRI. The benefits of ultrasound in the detection of salivary obstruction are numerous. Ultrasound is a noninvasive, portable, readily accessible, and highly sensitive tool for visualization of salivary stones.6,10,11 It reveals signal intensities that relate to the tissue type being examined, and thus, can highlight the parenchyma of a salivary gland. For this reason, it is excellent to highlight the presence or absence of obstruction; furthermore, it can differentiate between calculi, other anatomical structures, and pathological processes,12 allowing for rapid detection and diagnosis.

Although the superficial positioning of the submandibular gland makes it an ideal organ for ultrasound visualization, specific anatomical barriers may hinder stone localization. For example, stone size may present a problem for active stone localization, because those that are less than 3 mm in diameter may reduce sonographic visualization sensitivity.13 Additionally, a distal positioning of stones near the duct papilla is difficult to visualize by ultrasound. Past reports have shown diagnostic improvements when a counterforce is used during ultrasound examination.11

Drawing from the successes and limitations demonstrated by these reports, the senior author described a bimanual examination technique utilizing ultrasound.5 By placing a finger from the examiner's nondominant hand intraorally, a compressive counterforce is generated during the ultrasound examination. This method effectively decreases the distance between the skin and floor of the mouth and maximizes the quality of the scan, increasing the sensitivity of sialolith detection to near 97%.5 Furthermore, sonopalpation allows the operator to differentiate sialoliths from stenosis, which also presents with obstruction visualized on ultrasound alone.

In our practice, ultrasound evaluation is performed before, during, and after procedures in all of our patients. Some have suggested that ultrasound may not be needed in cases where a calculus can be easily palpated. We would assert that visualization of pathology during a procedure is always beneficial. Patients with chronic sialadenitis can develop areas of fibrosis and ductal scar, which can be mistaken for sialoliths. Additionally, in those patients with hypertrophic SMG and uncinate processes, a hilar stone can often be difficult to palpate. Ultrasound can help distinguish between scarred parenchyma and a true calculus.

Additionally, evaluation with ultrasound before and during surgical procedures can give us valuable information regarding surgical anatomy by helping to identify adjacent structures including blood vessels and muscles that may influence the surgical approach. For example, it may be useful to know that a superficial floor of mouth discoloration is not a plexus of veins prior to performing a transoral sialolithotomy.

Our data demonstrate complete stone removal in 90% of cases, the vast number of these cases being hilar stones (61%), with symptom resolution in 89.7% of patients. Strychowsky et al., in a meta-analysis of interventional techniques, described an 86% success rate of pure sialendoscopic methods and a 93% success rate of sialendoscopy with combined surgical approach,14 with success defined as symptom-free and absence of residual obstruction. Juul and Wagner described the success rates of transoral sialolithotomy to be 93%, with patient satisfaction at 94% and asymptomatic rates at 92%.15 Our success rates are similar to those published in the current literature. In our study, it is noteworthy that three patients did not return to the clinic, and they did not return a telephone call. Therefore, their symptom status is unknown. If we had 100% patient follow-up compliance, our patient satisfaction and overall success rates could potentially be higher than what is documented.

<table>
<thead>
<tr>
<th>Complications Encountered.</th>
<th>Successful</th>
<th>Failed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complications of the procedure</td>
<td>8 (4.9%)</td>
<td>5 (3.05%)</td>
</tr>
<tr>
<td>Stricture formation</td>
<td>5 (3.0%)</td>
<td>0</td>
</tr>
<tr>
<td>Ranula formation</td>
<td>3 (1.83%)</td>
<td>0</td>
</tr>
<tr>
<td>Severe Pain</td>
<td>0</td>
<td>3 (1.83%)</td>
</tr>
<tr>
<td>Bleeding</td>
<td>0</td>
<td>2 (1.22%)</td>
</tr>
<tr>
<td>Perforation</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nerve injury</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**TABLE III.**

<table>
<thead>
<tr>
<th>Symptoms Experienced Before Intervention.</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swelling</td>
<td>160 (97.6%)</td>
</tr>
<tr>
<td>Post-/periprandial</td>
<td>126 (76.8%)</td>
</tr>
<tr>
<td>Pain</td>
<td>122 (74.4%)</td>
</tr>
<tr>
<td>Discharge</td>
<td>55 (33.5%)</td>
</tr>
<tr>
<td>Xerostomia</td>
<td>28 (17.1%)</td>
</tr>
<tr>
<td>Xerophthalmia</td>
<td>8 (4.9%)</td>
</tr>
</tbody>
</table>

**TABLE IV.**

<table>
<thead>
<tr>
<th>Time to Completion of Sonolocation and Submandibular Sialolithotomy.</th>
<th>Successful</th>
<th>Failed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>20.2 ± 8</td>
<td>37.7 ± 10</td>
</tr>
</tbody>
</table>

<.0001
The use of sonolocation to perform transoral sialolithotomy, as opposed to a combined approach using sialendoscopy, is particularly useful in the office setting. Sonolocation and sialolithotomy can be performed efficiently with minimal resources and equipment. These procedures can be performed with the patient and surgeon, and often times with no assistant. The average time of successful surgical procedures, the majority of which were performed in the office setting, was 20.2 minutes from prep time to completion, with a high patient satisfaction rate, underscoring the efficiency of the technique. Combined procedures using sialendoscopy for SMG calculi, although similarly efficacious, can be quite cumbersome and requires more equipment and assistants.

Our study also shows the benefits of minimal complications. In our study, 1% of patients required sialadenectomy, which is similar to the rates published for other techniques.14 The small number of patients developing a stricture (five patients, 3.0%) and ranula (three patients, 1.83%) in this cohort were minimal, demonstrating safety.

The use of ultrasound for localization and treatment techniques had previously been demonstrated in the parotid glands, with rates of complete symptom resolution of 71%16 and 91%.17 This present investigation sought to focus on describing the level of precision by which ultrasound can localize stones and facilitate transoral submandibular sialolithotomy. We find that this is a helpful aid in those cases where patients may have symptomatic calculi, which may be difficult to palpate transorally by using a bimanual technique. It is particularly useful for those clinicians who wish to transition these cases to an office practice. It has been our clinical experience that using ultrasound allows for the safe and effective delivery of the calculus with minimal dissection and trauma than without some form of localization technique. The technique is readily learned by trainees and practitioners in minimal time.

CONCLUSION

Techniques for sialolith localization and treatment have been described in other reports with various success rates.15 Mastery of surgical technique is surgeon specific and directly proportional to experience. Modest et al. reported improved success rates for sialendoscopic treatment of stones over time.18 Once efficient ultrasound is accomplished, the we believe it is far easier to perform and can be repeated multiple times during any given procedure to localize pathology successfully. This report serves as an initial first series of patients in which ultrasound is utilized to localize pathology in real time during submandibular sialolithotomy.

BIBLIOGRAPHY