Sialoendoscopy

Prognostic Factors for Endoscopic Removal of Salivary Stones

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Objective: To detect prognostic factors for successful sialoendoscopic removal of salivary stones.

Design: Retrospective case series.

Setting: Tertiary referral hospital.

Patients: Forty-nine consecutive patients who underwent sialoendoscopy for sialolithiasis between January 1, 2008, and January 1, 2010, at University Hospital of Cologne, Cologne, Germany.

Interventions: Diagnostic and interventional sialoendoscopy using local anesthesia.

Main Outcome Measures: Stone removal rate, size, mobility, shape, and location, as well as clinical follow-up data.

Results: Sixty-one percent (39 of 64) of all salivary stones were removed endoscopically. The cutoff point for endoscopic removal was between 5 and 6 mm in stone diameter. Small size, good mobility, round or oval, and distal location of a salivary stone were positive prognostic factors for sialoendoscopic removal, with sialolith mobility having the greatest effect in multivariate analysis.

Conclusion: Small size, good mobility, round or oval, and distal location of a salivary stone in the main duct predict significantly greater probability of endoscopic removal and consequently are positive prognostic factors.


SIALOENDOSCOPY ALLOWS ENDOSCOPIC INTRALUMINAL VISUALIZATION OF THE DUCT SYSTEM OF MAJOR SALIVARY GLANDS AND ENABLES THE SURGEON TO DIAGNOSE AND TREAT INFLAMMATORY AND OBSTRUCTIVE DISORDERS OF THE DUCTS.1 ALTHOUGH OTHER PATHOLOGIC CONDITIONS ARE REGULARLY DIAGNOSED AND TREATED BY SIALOENDOSCOPY, SIALOLITHIASIS ACCOUNTS FOR ABOUT 50% OF INDICATIONS YET REPRESENTS THE MOST FREQUENT CAUSE OF UNILATERAL GLAND SWELLING. WHEN A SALIVARY STONE (SIALOLITH) IS NOT AMENABLE TO ENDOSCOPIC REMOVAL, VARIOUS TECHNIQUES, SUCH AS EXTRACORPOREAL OR INTRACORPOREAL FRAGMENTATION OR A COMBINED ENDOSCOPIC-EXTERNAL APPROACH, COME INTO PLAY.2,3 IN THE CASE OF LARGE SUBMANDIBULAR SIALOLITHS LOCATED FAR AWAY FROM THE OSTIUM, SOME SURGEONS INCISE WHARTON DUCT BEYOND THE HILUM OF THE GLAND INTO PARENCHYMAL AREAS, A PROCEDURE THAT CARRIES RISK OF DAMAGE TO THE LINGUAL NERVE.3,4 WHEN SIALOENDOSCOPY INCLUDES ADDITIONAL INTERVENTIONAL TECHNIQUES, OVERALL SIALOLITH EXTRACTION RATES BETWEEN 70% AND 95% HAVE BEEN REPORTED.1,3,4,10,11 EXCELLENT REMOVAL RATES EXCEEDING 90% MUST BE INTERPRETED CAREFULLY, AS THEY MOST OFTEN REPRESENT LATE CASE SERIES OF EXPERIENCED SURGEONS.12 DESPITE ITS APPARENT SIMPLICITY, SIALOENDOSCOPY IS A TECHNICALLY CHALLENGING PROCEDURE WITH A NOTABLE LEARNING CURVE; THEREFORE, SUCCESS RATES ARE PROPORTIONAL TO THE EXPERIENCE AND ENDOSCOPIC SKILLS OF THE SURGEON.12,13 HOWEVER, THERE IS DISAGREEMENT ABOUT WHAT SITUATIONS NECESSITATE FRAGMENTATION AND WHICH TECHNIQUE SHOULD BE USED PREFERENTIALLY. IT IS UNCLEAR WHEN EXTERNAL LITHOTRIPSY IS SUPERIOR TO INTERNAL LITHOTRIPSY, WHEN LASERS SHOULD BE USED INSTEAD OF A MANUAL BURR, OR WHEN A COMBINED PROCEDURE OR REMOVAL OF THE ENTIRE SALIVARY GLAND SHOULD BE PERFORMED IN LIEU OF INVASIVE FRAGMENTATION, SUCH AS DUCT INCISIONS. FRAGMENTATION TECHNIQUES ARE NOT UNIVERSALLY ALLOWED BECAUSE OF EARLY REPORTED Complications, AS WELL AS ADDITIONAL Instrument COST AND LEGAL REQUIREMENTS.12 LIMITATIONS FOR ENDOSCOPIC...
Sialolithiasis is a condition characterized by the presence of salivary stones (sialoliths), which can cause obstruction and subsequent inflammation. Early intervention is crucial to prevent complications such as infection and glandular damage. The study presented here aimed to evaluate the characteristics of sialoliths and the outcomes of endoscopic treatment, focusing on the maximum diameter of sialoliths as a significant factor for endoscopic removal success.

**METHODS**

Between January 1, 2008, and January 1, 2010, we performed 100 sialoendoscopic procedures at a tertiary referral center (University Hospital of Cologne, Cologne, Germany) using local anesthesia. For interventional sialoendoscopy, we used the following set of instruments (all from Karl Storz AG, Tuttingen, Germany): modular endoscope (11577 KE) or all-in-one endoscope (11574 A), together with Dormia basket (11582 M) or grasping forceps (11574 TJ and 11576 TJ). The rinsing solution consisted of a combination of lidocaine hydrochloride, 2%, with epinephrine in a ratio of 1:200,000 and sodium chloride, 0.9%, in a ratio of 1:10. The procedures were performed by 3 surgeons (J.C.L., D.B., and a colleague), all with experience in sialoendoscopy. The cases represented referrals for treatment of sialolithiasis following diagnostic sialoendoscopy. Approval of the local ethics committee was obtained for the study.

We retrospectively recorded patient descriptive data, characteristics of the intraoperative views, and the final outcome. The maximum diameter of all retrieved sialoliths was extracorporeally measured. The size of unretrievable sialoliths was measured extracorporeally after sialadenectomy or was measured using ultrasonography, which all patients underwent before surgery. If an unretrievable sialolith was not visualizable on preoperative ultrasonography and if the patient did not consent to sialadenectomy, size measurement was based on endoscopic estimation. All sialoliths were classified by mobility (mobile, adherent, adhesive, or fixed), shape (round, oval, or irregular), and location inside the duct system (main duct, hilum area, or intraglandular).

If a sialolith could not be removed endoscopically and if the patient had severe symptoms of sialolithiasis, we recommended surgical removal of the involved gland. In these cases, we reviewed the histopathologic report for sialolith number and size.

**RESULTS**

Sialoendoscopy revealed a diagnosis of sialolithiasis in 49 glands (among 49 consecutive patients who underwent sialoendoscopy). Of the patients, 26 were women and 23 men, and the mean age was 49.1 (1.9) years (age range, 23-80 years). The parotid gland was affected in 21 patients (12 left and 9 right) and the submandibular gland in 28 patients (11 left and 17 right). Patients reported the following preoperative symptoms: postprandial swelling of the gland (38 patients [78%]), swelling of the gland independent of ingestion (12 patients [24%]), and recurrent sialadenitis (5 patients [10%]). Patients had been affected by sialolithiasis-related symptoms for a mean of 63.4 months (range, 0.3-384 months) before interventional sialoendoscopy.

In total, 64 sialoliths were visualized during sialoendoscopy. Of these, 48 were detected on preoperative ultrasonography (sensitivity, 0.75). Nine patients had multiple sialoliths. Using the Dormia basket or grasping forceps inside the working channel of the endoscope, we were able to retrieve 39 sialoliths (removal rate, 60.9%). We failed to retrieve 25 sialoliths in 21 patients. We recommended sialadenectomy to these patients based on disease severity and symptoms. Twelve patients underwent sialadenectomy (2 parotid gland and 10 submandibular gland). The other 9 patients are receiving follow-up care.

The 39 sialoliths that could be removed had a mean maximum diameter of 3.7 (0.3) mm (range, 1.2-12 mm). The 25 sialoliths that were endoscopically unretrievable had a mean maximum diameter of 7.0 (0.5) mm (range, 4.1-13 mm) (Figure). The difference in diameter was statistically significant ($t = -5.99, P < .001$). For 26 removed sialoliths, the preoperative ultrasonographic measurement could be compared with the actual extracorporeal measurement. Ultrasonographic measurements were smaller for the removed sialoliths (mean, 3.4 mm) vs the unretrievable sialoliths (mean, 4.5 mm) ($P = .03$). The other 13 removed sialoliths were mostly small and could not be visualized during ultrasonography.

Twenty-one sialoliths having a maximum diameter of up to 3 mm could be removed. The removal rate decreased with increasing maximum diameter of sialoliths. Compared with a 91% (40 of 44) removal rate for sialoliths of up to 4 mm and an 80% (35 of 44) removal rate for sialoliths of up to 5 mm, the removal rate for sialoliths exceeding 5 mm dropped to 20% (4 of 20).

**Figure.** The maximum diameter of a sialolith is a prognostic factor for endoscopic removal, with about 5 mm being the cutoff point. The boxes indicate outliers; bars, at top and bottom, maximum and minimum; and line within shaded box, median.
The statistical 50% probability of sialolith removal was determined. The cutoff point for endoscopic sialolith removal was between 5 and 6 mm in stone diameter ($\chi^2=20.48$, $P<.001$).

Significantly smaller sialoliths were found in the parotid gland (mean diameter, 4.2 [0.3] mm; range, 2-10 mm) than in the submandibular gland (mean diameter, 5.7 [0.5] mm; range, 1-13 mm) ($t_{37,98}=-2.5$, $P=.01$). Twenty of 27 parotid gland sialoliths (74%) could be removed endoscopically compared with 19 of 37 submandibular gland sialoliths (51%).

In 2 patients, the size of the sialolith could only be estimated endoscopically. Both patients had endoscopically unremovable sialoliths that could not be detected by ultrasonography and for which the patients did not undergo surgery.

The shape of sialoliths in most patients was oval (n=42) vs round (n=4) or irregular (n=18). Oval or round sialoliths (35 of 46 [76%]) had significantly greater probability of removal than angled or irregular sialoliths (4 of 18 [22%]) ($\chi^2=15.8$, $P<.001$). Sialoliths in the parotid gland were mostly oval (n=21), followed by irregular (n=5) and round (n=1). A similar distribution was found for sialoliths in the submandibular gland, which were oval (n=21), irregular (n=13), and round (n=3).

Sialoliths located in the main excretory salivary duct (n=24) were retrieved in 79% (n=19) of patients. The mean maximum diameter of these sialoliths was 4.3 (0.4) mm (range, 2-12 mm). Most sialoliths (n=36) were located in the hilum area (56% [36 of 64]) or in the main excretory salivary duct (38% [24 of 64]) in both glands. Their mean maximum diameter was 5.8 (0.5) mm (range, 2-13 mm), and we were able to retrieve 47% (n=17) of these. The difference in removal rates for the main duct vs the hilum area was statistically significant ($\chi^2=6.12$, $P=.01$). Four sialoliths were found proximal to the hilum area in branches of the second or third generation. Three of these intra-glandular sialoliths were small (maximum, 3 mm) and freely floating inside the duct system and could be caught with the Dormia basket. In the parotid gland, one-half (n=14) of all sialoliths were located in Stenon duct and the other half (n=12) in the hilum area (n=12); only 1 sialolith was found in a second-generation branch. In the submandibular gland, most sialoliths (n=24) were stuck in the hilum area, while 10 were found in Wharton duct and 3 in second-generation branches.

Most sialoliths (n=39) were mobile, although usually not freely floating through the duct system because of consecutive stenoses or natural narrowing of the main duct. Of these mobile sialoliths, 92% (36 of 39) could be removed endoscopically. Twelve sialoliths were adherent to the endothelium and were consequently classified as adhesive. We could remove only 25% (n=3) of these. Full fixation of a sialolith to the endothelial tissue (n=13) led to a poor removal rate of 0%. Therefore, mobile sialoliths were removable significantly more often than adhesive or fixed ones ($U=76.5$, $P<.001$; Mann-Whitney test). Of 27 sialoliths in the parotid gland, 67% (n=18) were mobile compared with 19% (n=5) adhesive and 15% (n=4) fixed. Of 37 sialoliths in the submandibular gland, 57% (n=21) were mobile compared with 18% (n=7) adhesive and 24% (n=9) fixed.

In multivariate analysis, the dependent variables differed significantly between the endoscopically removable vs unremovable sialolith groups (Wilks $\Lambda=0.26$, $F_{4,99}=41.93$, $P<.001$). To clarify which variables contributed most to this result, we calculated a simultaneous discriminant analysis with size, mobility, shape, and location as predictors and with sialolith group as the outcome. Table 1 gives within-group correlations between variables and the discriminant function, as well as standardized $\beta$ weights. According to these coefficients, sialolith mobility had the greatest effect in multivariate analysis, followed by size, location, and shape.

The characteristics of all sialoliths are given in Table 2.

### Table 1. Coefficients in the Simultaneous Discriminant Analysis

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Correlation Coefficient</th>
<th>Standardized Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility</td>
<td>0.80</td>
<td>0.90</td>
</tr>
<tr>
<td>Size</td>
<td>0.45</td>
<td>0.60</td>
</tr>
<tr>
<td>Shape</td>
<td>0.34</td>
<td>-0.04</td>
</tr>
<tr>
<td>Location</td>
<td>0.13</td>
<td>0.18</td>
</tr>
</tbody>
</table>

### Table 2. Characteristics of Endoscopically Removable Sialoliths

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Parotid Gland (n=27)</th>
<th>Submandibular Gland (n=37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum size, mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-3</td>
<td>100 (10/10)</td>
<td>100 (11/11)</td>
</tr>
<tr>
<td>4-5</td>
<td>64 (9/14)</td>
<td>56 (5/9)</td>
</tr>
<tr>
<td>6-8</td>
<td>50 (1/2)</td>
<td>19 (2/11)</td>
</tr>
<tr>
<td>&gt;8</td>
<td>0 (0/1)</td>
<td>17 (1/6)</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main duct</td>
<td>79 (11/14)</td>
<td>80 (8/10)</td>
</tr>
<tr>
<td>Hilum area</td>
<td>75 (9/12)</td>
<td>33 (8/10)</td>
</tr>
<tr>
<td>Intraglandular</td>
<td>0 (0/1)</td>
<td>100 (3/3)</td>
</tr>
<tr>
<td>Shape</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Round</td>
<td>100 (1/1)</td>
<td>67 (2/3)</td>
</tr>
<tr>
<td>Oval</td>
<td>81 (17/21)</td>
<td>71 (15/21)</td>
</tr>
<tr>
<td>Irregular</td>
<td>40 (2/5)</td>
<td>15 (2/13)</td>
</tr>
<tr>
<td>Mobility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile</td>
<td>94 (17/18)</td>
<td>90 (19/21)</td>
</tr>
<tr>
<td>Adhesive</td>
<td>60 (3/5)</td>
<td>0 (0/7)</td>
</tr>
<tr>
<td>Impacted or fixed</td>
<td>0 (0/4)</td>
<td>0 (0/9)</td>
</tr>
</tbody>
</table>

The likelihood of sialolith removal depends on many factors. These can be related to patient variables, the pathologic disorder, the surgeon, or the set of instruments being used. In this study, we investigated the effect of sialolith variables, including size, mobility, shape, and location inside the duct system.

To date, few studies have reported explicit success rates for endoscopic removal of sialoliths without prior fragmentation. One study demonstrated an extraction rate...
of 35%, but the results were limited to patients with sialoliths in Stensen duct that exceeded 3 mm. Iro et al reported an extraction rate of 91.6% among 1522 patients using endoscopic means (wire basket and microforceps) as first-line treatment. Sialolith size of less than 5 mm was an inclusion criterion and “known fixed salivary calculi” an exclusion criterion for attempting endoscopic sialolith removal. Their extraction rate represents outcomes of experienced surgeons. If we apply the same inclusion criterion (size, <5 mm) to our group of patients, a similar success rate of 90% (28 of 31) was achieved in our series.

Authors have claimed that sialolith size is the most decisive variable in successful endoscopic removal. Our study findings support that size has a key role in the probability of extraction. The removal rate dropped to 20% (4 of 20) in our series for sialoliths exceeding 5 mm in maximum diameter. Stone size is initially assessed during preoperative ultrasonography, which should be a mandatory examination before sialendoscopy. Only sialoliths exceeding 2 to 4 mm are visible with ultrasonography, with a sensitivity of about 60% to 80%. In our series, the size of sialoliths was significantly underestimated during ultrasonography. This may represent limitations of ultrasonography, which cannot show each diameter or dimension of a sialolith. Because we noted no size overestimation in our series, it is tempting to speculate that ultrasonographic measurements can show only the minimal size of a sialolith.

In our experience, ultrasonography cannot provide exact information about whether a sialolith is endoscopically removable because different variables cannot be reliably investigated by the imaging method. While the location of a sialolith can be estimated, mobility and shape cannot be judged by ultrasonography at all. The reliability of size measurements is unclear. If size is the only known variable of a sialolith, it provides no information about removability, as a sialolith exceeding 5 mm may be amenable to endoscopic removal if the largest diameter is oriented favorably along the length of the duct and if other diameters are small enough. However, orientation of a sialolith inside the duct system cannot be revealed by ultrasonography. Although the size of a sialolith is an important variable, more characteristics need to be known to judge the probability of endoscopic extraction. As a consequence, ultrasonographic information alone does not suffice for triage of patients with sialolithiasis.

Not surprisingly, our study results showed easier removal of round or oval sialoliths than irregular sialoliths. Sialoliths that were fixed or partially integrated into the endothelial wall were usually of irregular shape; stones of this shape had a poor removal rate of 22% (4 of 18). Most sialoliths were located in the hilum area (56% [36 of 64]) or in the main excretory salivary duct (38% [24 of 64]) of both glands. It is tempting to speculate that the poorer removal rate of sialoliths in the hilum area (47% [17 of 36]) was because of their larger size compared with sialoliths in the main duct. The hilum area is the anatomic region that connects the main excretory salivary duct with second-generation branches in both glands. The duct system forms a bulge here; hence, sialoliths located in this area may have more anatomic space in which to expand. Consequently, the more distally a sialolith is located in the duct system, the greater is the probability of removing it endoscopically.

Mobility of a sialolith seems to be a factor of utmost importance in endoscopic removal. If a sialolith was classified as mobile, it had a 92% (36 of 39) probability of endoscopic removal in our series of patients. In fact, multivariate analyses showed that mobility was a better prognostic indicator of endoscopic sialolith removal than size. The percentage of mobile sialoliths (61% [39 of 64]) corresponded to the overall percentage of endoscopically removable sialoliths (61%; 39 of 64), although the subgroups do not include the same cases (3 mobile sialoliths were unremoveable and 3 adhesive sialoliths were removable). Sialoliths fixed to or embedded in the endothelial wall have almost no probability of being removed without the use of additional instruments. In fact, we encountered limited mechanical stability of the grasping forceps in 3 patients when trying to manipulate fixed sialoliths; consequently, this is not recommended. Instead, embedded sialolith formations may need more aggressive treatment such as long transoral duct incisions, combined endoscopic-external approaches with excision of the affected duct part, or fragmentation of the sialolith before sialendoscopy.

In conclusion, the probability of endoscopic sialolith removal depends to a great extent on anatomic and physiologic characteristics of the stone. In our patient population, 61% (39 of 64) of all sialoliths could be removed using more invasive or technically demanding endoscopic methods. Positive prognostic factors for sialoendoscopic removal include good mobility, round or oval shape, small size of less than 5 mm, and distal location in the main excretory duct of the salivary gland, with sialolith mobility being most predictive of successful endoscopic removal.

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Author Contributions: Drs Luers, Grosheva, and Beutner had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Luers, Grosheva, and Beutner. Acquisition of data: Luers, Grosheva, and Beutner. Analysis and interpretation of data: Luers, Stenner, and Beutner. Drafting of the manuscript: Luers and Beutner. Critical revision of the manuscript for important intellectual content: Luers, Grosheva, Stenner, and Beutner. Statistical analysis: Luers and Grosheva. Study supervision: Beutner.

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