Intraductal Lithotripsy in Sialolithiasis Using the Calculase III™ Ho:YAG Laser: First Experiences

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Background and Objectives: To report the first experiences with a newly available Ho:YAG laser system for the treatment of salivary stones.

Study Design/Materials and Methods: A retrospective study in a tertiary referral center was conducted. Patients diagnosed with sialolithiasis were treated in Erlangen using the Calculase III™ Ho:YAG laser (Karl Storz, Tuttingen, Germany). Preset parameters had a frequency of 4 Hz and energy of 0.8–1.2 J, resulting in 3.2–4.8 W. Following total fragmentation, one to two serial sialendoscopies were performed to achieve complete fragment clearance.

Results: A total of 55 stones in 49 patients were treated; 17 stones in 15 submandibular glands and 38 in 34 parotids. In total, 61 laser lithotripsies (range 1–3 per stone) were performed using various modes (long, short, and burst) and with preset parameters of 4 Hz and energy of 0.8–1.2 J, resulting in effective power of 3.2–4.8 W. Complete fragmentation was achieved in all the accessible stones. Sialendoscopes, fibers, or the mode used had no significant influence on success rates. A multimodal therapy concept was employed to treat stones in 12.24% of the cases; 95.92% of the patients were ultimately stone-free, and all became symptom-free. All glands were preserved.

Conclusions: The new Calculase III™ Ho:YAG laser was effective in the treatment of sialolithiasis with no increased risk of complications in the patients or damage to the sialendoscopes. Clinical factors such as the type of gland involved, or the location and size of stones had a greater impact on success rates than the technical or preset parameters. Lasers Surg. Med. © 2020 Wiley Periodicals LLC

Key words: intraductal lithotripsy; laser; sialolithiasis; salivary gland; sialendoscopy; treatment

INTRODUCTION

Sialendoscopy-controlled extraction of small and mobile salivary stones is now regarded as the treatment of the first choice in patients with sialolithiasis. However, over 80% of the stones require prior fragmentation. The past two decades have seen the introduction of various methods, such as extracorporeal shock wave lithotripsy (ESWL) and sialendoscopy-controlled intraductal fragmentation [1–16]. The most remarkable developments during the last 5–10 years have been in the field of intraductal lithotripsy (IDL), where intraductal laser lithotripsy (LL) and pneumatic lithotripsy (IPL) are now the favored techniques. Success rates of over 80% have been reported for IPL [6,17,18]. Although LL has been performed for more than 20 years [19–36], inconsistent and variable success rates have been reported, supposedly caused by poor laser techniques and/or because no suitable sialendoscopes were available. This changed after the development of more advanced sialendoscopes [24,25,37–43] and, in particular, after the improvement of instruments needed to perform effective laser surgery in salivary ducts [7]. Of the currently available lasers, the Ho:YAG laser was shown to be the most suitable [44]—as confirmed by success rates of more than 80% in recent publications [31–35]. We recently showed that salivary stones could be effectively treated with the Calculase II™ Ho:YAG laser [45].

The purpose of this study was to describe our first experiences in the use of a new Ho:YAG laser system (Calculase III™; Karl Storz, Tuttingen, Germany), which is now certified and available for use in salivary ducts.

PATIENTS AND METHODS

This retrospective study was carried out in the Department of Otorhinolaryngology, Head and Neck Surgery at the FA University of Erlangen–Nuremberg, Germany. The study was conducted in accordance with the Helsinki Declaration; approval was obtained from the local institutional review board.
From December 2018 to April 2020, patients diagnosed with sialolithiasis using ultrasound were treated with LL (Calculase III™; Karl Storz; Fig. 1). The indication to perform LL in the parotid gland (PG) was every stone adequately accessible with the sialendoscope. In the submandibular gland (SMG) every stone which was accessible by sialendoscopy and could not be treated adequately by methods of transoral duct surgery LL was indicated. The indications were performed according to the department’s proven treatment algorithms [9,17,45] and in conjunction with our experiences in the use of pneumatic lithotripsy [17] or LL using the Calculase II™ laser [45].

Patient data were recorded, reviewed, and parameters analyzed on the basis of individual stones or per patient. LLs were carried out in 48 patients under local anesthesia using 5–10 ml Articaine 2% (Ultracain®; Sanofi-Aventis, Frankfurt, Germany) injected intraductal and into the cheek mucosa and after prior peroral application of 15–30 drops Tilidine (Valoron®; Aljud Pharma, Lauchingen, Germany). In very deep, hilar to posthilar, stone location, local anesthesia was also administered directly into the gland parenchyma in single cases to improve access to the stone by a more vigorous manipulation. In one patient (8-year-old child), LL was performed under general anesthesia.

Two sialendoscopes (1.1 and 1.6 mm) were included in the Erlangen set (Karl Storz) [12,17] and one sialendoscope from the Marchal set (1.3 mm) [24,25,38,39] were used to perform LL. Insertion of the sialendoscopes could be achieved regularly after stepwise dilation of the ostium (PG, SMG) or retropapillary duct incision (SMG) [9,17]. The distal 5-grade angulation of the 1.3 mm or the stiffness of the 1.6 mm sialendoscope was helpful to approach deeply located parotid stones.

The Calculase III™ is a low-powered Ho:YAG laser system (maximum power 35 W) now certified and available for the treatment of sialolithiasis. The pulse frequency (4–30 Hz) and the energy/pulse (0.2–4 J) can be variably preset. There is a choice of three pulse modes: “short” (90–450 microseconds), “long” (450–2000 microseconds), and the recently described “burst” mode [46–48] in which a number of laser pulses are emitted in short succession and whose total energy corresponds to a normal, single destruction pulse. The individual burst pulses are significantly shorter in time and their average power is less than a conventional destruction pulse. Each burst pulse has a duration of under 270 microseconds, leading to an overall pulse duration of approx. 2–4 milliseconds. However, the overall pulse duration depends on the preset energy level. The higher the energy level, the more single pulses are applied. While the effect of the burst pulses is comparable to that of a single pulse, nonlinear effects that produce a repulsion of the stone can be reduced or even avoided.

The laser energy is released by a food paddle and transferred via laser fibers that fit through the endoscope’s different working channels (235 µm/1.1 and 1.3 mm; 235 and 365 µm/1.6 mm sialendoscope, Fig. 2). A green pilot laser beam indicates the exact position of the effective laser beam. Low pulse frequencies (4 Hz), variable energy levels (0.8–1.2 J) resulting in a variable power (3.2–4.8 W) were used depending on the size of the sialendoscope and anatomy of the duct system. Due to the higher vulnerability of the smaller 1.1 and 1.3 mm sialendoscopes, only lower energy levels (0.8 J, 3.2 W) were used with those instruments. Experiences we had gained when using the Calculase II™ laser were helpful [45]: the fiber tip was accordingly in direct contact with the stone’s surface, visual control was provided by a green pilot laser, and intensive continuous irrigation was performed to avoid thermal damage to the tissue or sialendoscopes (Figs. 3–6). Fragments were removed with the basket...
and/or grasping forceps. Stent implantation was performed in the case of duct wall maceration and/or if accompanying stenosis was being treated and especially if signs of insufficient gland function were present [17,43].

Aftercare and follow-up examination were conducted as described elsewhere [9,17]. Clinical ultrasound examinations and follow-up sialendoscopy were planned after 4–12 weeks. If a patient was unwilling or unable to attend the follow-up examinations, the otolaryngologist was consulted and a telephone interview was carried out. Insufficient gland function was suspected first, if only very few amounts of secretion (not more than 0.5–1 ml) could be expressed, even when gland massage was performed after stimulation. Second, if a tendency to develop local or diffuse stenosis, in some cases, also a tendency to ductal obliteration was visible when SE was performed. Third, if no complaints or significant gland swelling were reported by the patients and the gland parenchyma was hypoechoic in U.S. examination.

The endpoints of our study were the rate of complete stone fragmentation, stone-free and symptom-free rates, and complication-free status.

**Statistical Analysis**

The software program IBM SPSS Statistics for Windows, version 24, was used (IBM Corporation, Armonk, NY). All data are given as means ± SEM, range, and median. Bivariate correlations were calculated using the Pearson correlation coefficient. Differences between groups were calculated using the Mann–Whitney U test; differences between categorical variables using the $\chi^2$ test. The significance level was $P \leq 0.05$.

**RESULTS**

Fifty-five stones in 49 patients were treated by LL using the Calculase III™ laser. Twenty-two patients were male, 27 female, and the mean age was 50.1 years (median 53,
range 8–75). Seventeen stones were in the submandibular gland (SMG, Figs. 3 and 4) and 38 in the parotid (PG, Figs. 5 and 6). Sixty-one LLs were carried out (two in six and three in three patients), 60 under local anesthesia, and only one under general anesthesia (8-year-old child).

The stones were 2.5–14 mm in size (6.04 ± 0.35) and 52.72% were located proximal to intraparenchymal tissue. The location of treated stones was significantly different in the two glands (P ≤ 0.0001) and parotid stone size tended to be bigger (P ≤ 0.053; Table 1).

A mean of 1.11 (range 0.3–3) LLs per stone was performed. The mean procedure duration was 59.87 ± 5.2 min. Stone size was positively correlated with the number of pulses (all glands, P ≤ 0.0001; PG P ≤ 0.001 and SMG, P ≤ 0.002), the amount of energy or power/stone to achieve complete fragmentation (P ≤ 0.0001/all glands, SMG, PG), and procedure duration (all glands P ≤ 0.028; PG P ≤ 0.03, SMG P ≤ 0.031). Although compared with parotid stones, submandibular stones needed a larger number of pulses/stone and greater energy/stone to achieve complete fragmentation, the differences were not significant (Table 1).

Forty-three stones (78.18%) were fragmented with the 1.6 mm, 9 (16.36%) using the 1.1 mm, and 3 (5.45%) using the 1.3 mm sialendoscope, with no significant differences between PG and SMG. The 0.365 mm fiber was used in 67.9% of stones. Details concerning use of laser fibers, pulse mode, and sialendoscopes in the two glands are shown in Table 2.

All accessible stones could be completely fragmented in both glands. Intra-glandular or inter-glandular comparison revealed that laser fiber diameter had no significant effect on the number of pulses/stone or energy/stone needed for complete fragmentation. Similarly, no significant associations were observable between the number and duration of LLs per stone, the LLs mode, or between location and size of stones and diameter of the laser fibers.

Due to the expected reduction of retropulsion effects, the “burst” mode was the first choice and therefore used

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Fig. 3. (A-D) Posthilar stone (3.8 mm, SMG): ultrasound view (A) and sialendoscopic view showing the stone (B, black arrow) and the posthilar duct division (B, white arrow). Situation during LL, showing the laser fiber in contact with the stone surface (C) and after completion of the procedure showing the former stone bed (D, black arrow). MM, mylohyoid muscle; SMG, submandibular gland; ST, stone; T, tongue.
for most stones (41/55, 74.55%, Table 2). Several modes were used in three stones, but only the finally chosen mode was counted (first stone—PG, hilar, 6.3 mm: changing from “short” to “burst”; second stone—SMG, posthilar, 4 mm: changing from “long” to “burst”; third stone—SMG, posthilar 3.9 mm: changing from “short” to “burst”). The changes were intended to reduce the retropulsion effect and/or risk of imminent duct perforation. Due to the known increased fragmentation effect, some bigger stones—obviously not associated with the risk of retropulsion—were primarily treated by the “long” pulse mode. A tendency to treat bigger-sized stones more often by “long” pulse mode was noted (P ≤ 0.08). However, in general, the fragmentation mode had no significant impact on any of the parameters concerning stones or LL procedures.

Multiple stones were treated in 11/49 cases (22.45%) significantly more often in the SMG (P ≤ 0.05). LL was the only treatment modality in 6/49 (12.24%, up to three stones) or part of multimodal treatment in 5/49 (10.20%) cases. The latter was significantly more often indicated in SMGs (P ≤ 0.026, Table 3).

ESWL was part of the therapy concept in 10/49 cases (20.40%). It was performed simultaneously in 3/49 cases due to difficulties in accessing the stones (two PG with simultaneous stenosis, one SMG with multiple sialolithiasis). ESWL was performed before LL in six cases, but was part of our current treatment regime in only two

Fig. 4. (A, B) Situation 6 weeks after LL of a posthilar stone (3.8 mm) SMG: sialendoscopic view showing the former stone bed (A, black arrow) and ultrasound view showing duct diameter of 1.4 mm (B). MM, mylohyoid muscle; SMG, submandibular gland; T, tongue; WD, Wharton’s duct.
cases. In one case, ESWL was performed after LL because of the retropulsion of a stone fragment (Table 3).

Transoral duct surgery (TDS) was part of multimodal therapy in 4/49 cases (8.16%). LL could be performed through a neo-ostium in one case due to a residual stone after successful TDS and in three cases with persistent stones where TDS was unsuccessful (two cases with multiple sialolithiasis). In another three patients, LL was used to treat recurrent stones after successful TDS (one case after TDS and IPL, Table 3).

Stent implantation was performed in 27/49 (55.10%) patients, significantly more often in the PG (26 cases) compared to SMGs ($P \leq 0.0001$). 19/49 (48.76%) of the stents were implanted due to maceration of the duc tal epithelium and/or presence of residual fragments, papilla swelling or especially if signs of insufficient gland function were present. In 8/49 cases (16.32%) stents were implanted because of accompanying duct stenosis. In eight patients (16.32%), signs of insufficient gland function were observed at presentation, and gland atrophy and duct obliteration were noted in one of them. Prolonged stent implantation was necessary in two cases (one case illustrated in Figs. 5 and 6).

Following our earlier experiences [49], relevant damage to the sialendoscopes was avoided by the application of a maximum of 3.2 W with the smaller sialendoscopes and by keeping a distance of at least 0.5 cm between the sialendoscope tip and stone surface. In most cases a varying degree of ductal maceration was observed, which—if too pronounced—was treated by prophylactic stent implantation. Duct perforation occurred in four cases (8.16%) and simultaneous low- or high-grade stenosis proximal to the stone was present in three of them. Serial stent implantations were necessary in two patients because of simultaneous resistant stenosis combined with insufficient gland function; the other two cases healed.

Fig. 5. (A–D) Ultrasound view showing proximal parotid stone (13.9 mm, (A) and sialendoscopy showing stone (green arrow) with accompanying stenosis (black arrow, B). Situation during LL, showing the laser fiber with a green pilot laser beam in contact with the stone surface (C) and after LL showing profound maceration of the epithelium (black arrow) and duct lumen (white arrow, D). M, mandible; MM, masseter muscle; PG, parotid gland; SD, Stensen’s duct; ST, stone.
satisfactorily. No parameter—especially the fragmentation mode or fiber used—had any significant influence on the rate of complications.

Follow-up endoscopies were carried out on the first and second days in all cases. Forty-seven patients had another control sialoendoscopy after 4-12 weeks (Figs. 4A and 6A). All patients except one had a follow-up examination after 4-12 weeks with US (Figs. 4B and 6B). US was performed considering criteria described earlier [50]. The child was examined clinically and by ultrasound after 10 weeks, another patient (physician’s colleague) was not able to present in the short time interval, and follow-up was performed by himself and by colleagues in his own hospital. He was contacted by phone after 6 months. All patients ultimately became symptom-free and all glands were preserved. Forty-seven out of 49 (95.92%) of the patients became stone-free. One patient had a second stone located intraparenchymally (SMG). To get stone-free, ESWL was offered, but delayed due to missing complaints at this time.

**DISCUSSION**

These results confirm the effectiveness of the Calculase III™ Ho:YAG laser for treating sialolithiasis in major salivary glands. The rates of complete fragmentation and freedom from symptoms were each 100%. Stone-free rates of nearly 96% were below the fragmentation rate of 100% because of the presence of additional intraparenchymal stones or residual fragments (Table 1). This study confirms our results on the use of Calculase II™ laser system,
TABLE 1. Parameters With Regard to Stones, LL Procedures, Complete Stone Fragmentation Rates, and Symptom- and Stone-Free Rates of Patients After LL of Sialolithiasis of the Major Salivary Glands (49 Patients, 55 Stones)

| Parameter | All glands (patients n = 49, stones n = 55) | Submandibular glands (patients n = 15, stones n = 17) | Parotid glands (patients n = 34, stones n = 38) | Mann–Whitney U test PG vs. SMG |
|-----------|--------------------------------------------|----------------------------------------------------|-----------------------------------------------|--------------------------------|
| Stone size (mm) | 6.04 ± 0.35 (M 5.2; R 2.5–14) | 5.43 ± 0.62 (M 4.0; R 2.5–10) | 6.28 ± 0.45 (M 5.45; R 3.6–14) | n.s. (P ≤ 0.053) |
| Location of stones: | | | | |
| Distal (n) | 13 (23.64%) | – | 13 (34.21%) | |
| Middle (n) | 13 (23.64%) | – | 13 (34.21%) | |
| Proximal to intraparenchymal (n) | 29 (52.72%) | 17 (100%) | 12 (31.58%) | |
| Number of LL/stone (n) | 1.11 ± 0.076 (M 1.0; R 0.3–3) | 1.12 ± 0.13 (M 1.0; R 0.5–3) | 1.17 ± 0.098 (M 1.0; R 0.3–3) | n.s. |
| Number of pulse/stone (n) | 261.31 ± 31.12 (M 217; R 14–1117) | 317.35 ± 71.24 (M 259; R 35–1117) | 240.41 ± 34.38 (M 185; R 14–724) | n.s. |
| Energy/stone (J) | 256,40 ± 34.27 (M 207.2; R 20.4–1340.40) | 356,0 ± 109.63 (M 238.6; R 36–13,4040) | 233.09 ± 34.57 (M 238.6; R 36–1,340.40) | n.s. |
| Power/stone (W) | 64.52 ± 8.53 (M 48.3; R 5.1–335.1) | 80.83 ± 21.26 (M 54.2; R 9.0–335.1) | 58.96 ± 8.54 (M 48.3; R 5.1–222.6) | n.s. |
| Duration of LL/stone (min) | 59.87 ± 5.20 (M 50; R 15–176) | 66.47 ± 9.98 (M 54; R 15–172) | 59.47 ± 6.64 (M 51; R 18–176) | n.s. |
| Number of stones with complete fragmentation (n, %) | 55/55 (100%) | 17/17 (100%) | 38/38 (100%) | n.s. |
| Number of symptom-free patients (n, %) | 49/49 (100%) | 15/15 (100%) | 34/34 (100%) | n.s. |
| Number of stone-free patients (n, %) | 47/49 (95.92%) | 13/15 (86.67%) | 34/34 (100%) | n.s. |

*Two patients with multiple sialolithiasis: first case intraparenchymal second stone (SMG), second case residual stone intraparenchymal (PG), all symptom-free.

TABLE 2. The Different Modes, Laser Fibers, and Sialendoscopes Used in LL for the Treatment of Sialolithiasis of the Major Salivary Glands (49 Patients, 55 Stones)

| Glands parameter | All glands (patients n = 49, stones n = 55) | Submandibular glands (patients n = 15, stones n = 17) | Parotid glands (patients n = 34, stones n = 38) | Mann–Whitney U test PG vs. SMG |
|------------------|--------------------------------------------|----------------------------------------------------|-----------------------------------------------|--------------------------------|
| Pulse mode: | | | | |
| Short (n) | 2 (3.63%) | 0 (0%) | 2 (5.26%) | |
| Long (n) | 8 (14.54%) | 3 (17.64%) | 5 (13.16%) | |
| Burst (n) | 45 (81.81%) | 14 (82.35%) | 31 (81.57%) | |
| Laser fiber | | | | |
| 365 µm (n) | 37 (67.27%) | 13 (76.47%) | 24 (63.16%) | n.s. |
| 235 µm (n) | 18 (32.72%) | 4 (23.53%) | 14 (36.84%) | |
| Sialendoscope | | | | |
| 1.1 mm (n) | 9 (16.36%) | 2 (11.76%) | 7 (18.42%) | |
| 1.3 mm (n) | 3 (5.45%) | – | 3 (7.89%) | |
| 1.6 mm (n) | 43 (78.18%) | 15 (88.24%) | 28 (73.68%) | |
especially certified for salivary stones [45] and also earlier results on the application of LL, in particular, various Ho:YAG lasers [30,32–35,44].

The location of stones treated in the two glands was significantly different ($P \leq 0.0001$), probably due to the different spectrum of indications for intraductal lithotripsy in them [9,17,45]. The size of treated stones was positively associated with the number of pulses and the amount of energy or power needed to achieve complete fragmentation ($P \leq 0.0001$ in each case). These data underscore that adequate accessibility is of paramount importance for the effective performance of LL. This applies to both major salivary glands since no significant differences in these parameters were noted between them. The anatomical specificities of the duct system may be why—despite the larger size of stones in PGs—a multimodal treatment ($P \leq 0.026$) was required and multiple stones ($P \leq 0.050$) had to be treated significantly more often in SMGs (Tables 1 and 3). TDS is part of a multimodal treatment in SMG to achieve or complete successful treatment in primary or recurrent stones [17,49], while ESWL is of primary importance in PG and SMG in stones not visible or accessible with any sialendoscope with the option to improve the possibility to perform interventional SE/LL (Table 3) [51]. The data presented here again demonstrate that LL seems to be a more elaborate procedure in SMGs than in PGs for reasons reported by us previously [17,45] and in other publications [52–55], which emphasize the importance of anatomical specificities of the duct system.

All laser fibers were effective for stone fragmentation in both glands, with no significant differences between them. Because greater fiber diameters are expected to result in a higher fragmentation effect, bigger laser fibers were used whenever possible (67.27% of the cases, Table 2). However, their use was mainly dependent on the availability of a working channel of adequate diameter, which is present only in the bigger sialendoscopes (≥1.6 mm). The ductal diameter and anatomy—but not the stone size—obviously influenced the choice of the sialendoscope and laser fiber. Of the smaller sialendoscopes, the 1.3 mm sialendoscope was used only in parotid ducts (Table 2). The latter has a favorable 5° angled tip and is, therefore, better suited for deeper insertion into the proximal/intraparenchymal duct system if downward curving is considerable. The treatment mode had no significant influence on the most relevant parameters in the two glands. The “burst” mode was used in over 81% of cases in both glands in order to reduce the retropulsion of stones or fragments and had no negative impact on effectiveness [46–48]. Retropulsion can occur in the small, curved submandibular ducts, but particularly in the straighter

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### TABLE 3. LL in Complicated Sialolithiasis in the Major Salivary Glands (49 Patients, 55 Stones): Rate of Stent Implantation, Use After TDS or in Combination With ESWL, LL as Part of a Multimodal Therapy Concept or LL in the Treatment of Multiple Stones

| Glands parameter (n, %) | All glands (patients n = 49, stones n = 55) | Submandibular glands (patients n = 15, stones n = 17) | Parotid glands (patients n = 34, stones n = 38) | Mann–Whitney U test PG vs. SMG |
|------------------------|------------------------------------------|------------------------------------------|------------------------------------------|-------------------------------|
| Stent implantation after LL (n cases) | 27 (55.10%) | 1 (6.67%) | 26 (76.47%) | $P \leq 0.0001$ |
| LL after prior TDS (n stones) | 7 (14.28%) | 7 (46.67%) | 0 (0%) | $P \leq 0.0001$ |
| Residual (n stones) | 1 (2.04%) | 1 (5.88%) | – | – |
| Persistent (n stones) | 3 (5.45%) | 3 (17.64%) | – | – |
| Recurrent (n stones) | 3 (5.45%) | 3 (17.64%) | – | – |
| LL in combination with ESWL | – | – | n.s. | – |
| Pre-interventional (n stones) | 6 (10.90%) | 2 (11.76%) | 4 (10.52%) | – |
| Simultaneous (n stones) | 3 (5.45%) | 1 (5.88%) | 2 (5.26%) | – |
| Post-interventional (n stones) | 1 (2.04%) | 1 (5.88%) | – | – |
| LL as part of multimodal treatment (single or multiple stones) | 5 (7.27%) | 4 (26.67%) | 1 (2.94%) | $P \leq 0.026$ |
| Interv. SE + LL | 1 (2.04%) | 1 (6.67%) | – | – |
| Interv. SE + LL + ESWL | 1 (2.04%) | 1 (6.67%) | – | – |
| ESWL + LL | 1 (2.04%) | – | 1 (2.94%) | – |
| TDS + LL | 1 (2.04%) | 1 (6.67%) | – | – |
| TDS + LL + ESWL | 1 (2.04%) | 1 (6.67%) | – | – |
| LL in the treatment of multiple stones (n cases) | 11 (22.45%) | 6 (40.0%) | 5 (14.70%) | $P \leq 0.050$ |
| monomodal by LL | 6 (12.45%) | 2 (13.33%) | 4 (11.76%) | n.s. |
| multimodal | 5 (10.20%) | 4 (26.67%) | 1 (2.94%) | n.s. |

ESWL, extracorporeal shock wave lithotripsy; interv. SE, interventional sialendoscopy; LL, laser lithotripsy; TDS, transoral duct surgery.
parotid ducts in the case of ductal dilatation. Retropulsion was the reason why one of the patients was not stone-free at the time of data sampling. In this case, the “long” mode was employed. If used, the “long” mode was preferentially chosen for large stones with impaction and/or reduced risk of retropulsion. The “short” mode was used where heat was to be avoided, and smaller and/or smoother stones were present, as was the case in the only child treated. Complications developed in simultaneous stenosis proximal to the stone (66.7%, PG) or in small duct diameters (33.3%, SMG). Although the “burst” mode was used in all cases, our data indicate that the fragmentation mode had no significant influence on the complication rate.

Problematic sialolithiasis was always the indication for LL. It is characterized by a poorly accessible location and/or difficult ductal anatomy and/or presence of multiple stones. 22.45% of such cases were treated because of multiple stones, 12.45% by LL alone. In 10.2%, LL was part of multimodal therapy for multiple stones. Both situations were present significantly more often in SMG (Table 3). Recent publications have shown the value of IDL in these complex situations. As in the present study and also in those cited here, methods of IDL provided success rates of over 90–95%. IPL was of superior importance when used in combination with ESWL in both glands [51] or in persistent, residual, or recurrent submandibular stones after prior TDS in SMGs [49]. The difficulty of LL was also evident from the fact that stent implantation was performed in 55.1% of patients, in 12.22%, due to an accompanying stenosis. In all but one case, the PG was affected, often due to a natural narrowness of the duct system.

The energy levels and power applied in LLs depended mainly on the anatomical situation of the duct system, which determined the choice of sialendoscope. With smaller sialendoscopes and/or smaller salivary ducts, 0.8 J/pulse resulting in 3.2 W was not exceeded even when stone size was in the bigger range (e.g., >7 mm). Higher energy levels (1.2 J/pulse) with consequently higher levels of power (4.8 W) were applied in combination with the 1.6 mm sialendoscope. Due to the natural narrowness of the natural ostium, initial papillotomy/ductal incision is often needed in submandibular ducts to insert sialendoscopes with bigger diameters. Our pulse frequency of 4 Hz can be recommended if fragmentation and not vaporization of a stone is intended and an uncontrolled tendency to retropulsion of stones or fragments is to be avoided. As shown by the 100% fragmentation rate of accessible stones, all our chosen preset parameters contributed to adequate stone fragmentation. As our results indicated and according to our recent experiences, nearly all residual/retropulsed fragments were washed out spontaneously, and retained fragments were observed in single cases only, for whom ESWL was considered the treatment of choice [17,45,49].

This technique enabled effective LL to be performed without pronounced damage to the instruments or sialendoscopes. Seventy percent of all complications were associated with duct stenosis that required simultaneous treatment. In particular, no significant stenosis in a primarily unaffected duct system was noted during follow-up.

CONCLUSIONS

Results with the new Calculase III™ Ho:YAG laser confirm our recent report [45] and others in the literature [45], which show that intraductal LL can be performed successfully, effectively, and safely. LL is particularly indicated for patients with problematic or complicated sialolithiasis. Stone size, location, and stone accessibility, and above all, the ductal anatomy, are the most important parameters for successful management. Depending on the sialendoscope, different laser fibers can be used, so extending the possibilities for performing LL even with smaller diameter ducts. Our preset parameters (frequency 4 Hz, energy/pulse 0.8–1.2 J, power 3.2–4.8 W) achieve effective stone fragmentation and avoid complications, with a simultaneous balancing of photo-mechanical and photo-thermal effects on stones or tissues [32–55,44,45].

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