Current concepts in diagnosis and treatment of sialolithiasis

Sialolithiasis is one of the most frequent causes of inflammatory changes within the major salivary glands in Europe. Salivary stone formation affects the submandibular gland in 80%, the parotid gland in 20% of cases, and rarely the sublingual gland.

Sialolithiasis is one of the most common causes of inflammatory disorders of the major paired salivary glands. The incidence for symptomatic sialolithiasis ranges between 27.5 and 59 cases per million (Escudier and McGurk, 1999). For England, the incidence is estimated at between 1300 and 3000 cases per year.

In most patients, salivary stones are detected in the major paired salivary glands, i.e. in the submandibular gland (63–95%), parotid gland (6–21%) or sublingual gland (0–16%), and very rarely in the numerous minor salivary glands (lingual, palatinal, buccal and pharyngeal glands) (Lustmann et al, 1990; Zenk et al, 1999).

The parotid gland is the largest of the major salivary glands. Stensen's duct is approximately 5–6 cm long. It passes horizontally across the masseter muscle before it bends around its anterior edge to pierce the buccinator muscle and the oral mucosa. Finally, it empties into the oral cavity opposite the upper second molar tooth. The diameter of the parotid duct is 1.4 mm in the hilum, 1.2 mm when it passes through the buccinator muscle and 0.5 mm at the ostium (Zenk et al, 2004b).

The seromucous submandibular gland is localized between the anterior and posterior belly of the digastric muscle and the hyoglossal muscle. The submandibular duct, which is 5–6 cm long, wraps around the posterior edge of the mylohyoid muscle, crosses the lingual nerve and runs within the floor of the mouth until it empties into the sublingual papilla. The mean diameter of the submandibular duct is 1.5 mm from the hilum to the ostium and 0.5 mm at the ostium (Zenk et al, 2004b).

The mucoserous sublingual gland is situated in the floor of the mouth, above the mylohyoid muscle and below the oral mucosa, thus producing the sublingual fold. The sublingual duct either joins the submandibular duct or drains directly into the sublingual papilla.

In the past 10 years, numerous minimally invasive treatments for sialolithiasis have been developed and established in clinical practice. This article will review current therapeutic strategies and discuss their clinical relevance.

Professor H Iro *is Professor and Chair,* **Dr J Dlugaiczyk** *is Resident and* **Professor J Zenk** *is Professor and Vice Chair of the Department of Otorhinolaryngology, Head and Neck Surgery, University of Erlangen-Nuremberg, Germany D-91054 Erlangen*

Correspondence to: Professor H Iro

Clinical findings in sialolithiasis

Salivary calculi predominate in patients between their 30s and 40s. However, sialolithiasis has also been observed in children (Zenk et al, 1999). The youngest patients in the authors' population (n>1400) were a 5-year-old girl and a 3-year-old boy. A causal correlation between sialolithiasis and an underlying systemic disorder or a common cause for generalized stone development in the urinary tract, the bile duct system and the salivary ducts has often been discussed in the literature. However, this hypothesis could not be verified in a clinical study (Zenk et al, 1999).

Localization of salivary stones in the duct system of the affected gland is decisive for a differential therapeutic approach: in the submandibular gland, 9% of stones are found in the intraglandular ducts, 57% near the hilum and 34% in distal Wharton's duct. Approximately 23% of parotid stones are localized in the intraglandular ducts, 13% in the hilum and 64% in the distal part of Stensen's duct (Zenk et al, 1999).

If the salivary duct system is partially or completely congested by a sialolith, symptoms become manifest following induced secretion. Around 50% of patients present with painful swelling of the affected salivary gland (salivary gland colic) and 46% with swelling only. After secretion of saliva has stopped, the symptoms usually resolve gradually. Patients report a history lasting anything from a few days up to several years. Of cases 1% are diagnosed as incidental findings, e.g. during dental examination (Zenk et al, 1999).

In cases of a prolonged course of disease, swelling is a sign of persisting congestion of the salivary duct system. Gland massage in acute inflammatory episodes leads to purulent discharge into the ostium of the salivary duct, resulting in sensations of bad taste.

Abscess formation, phlegmonous inflammation or sialo-cutaneous and sialo-oral fistulas are possible complications of obstructive sialadenitis.

Diagnosis

Sialolithiasis should be considered in every case of unclear swelling of salivary glands or sialadenitis. Stones of distal Wharton's duct and the hilum can be detected by bimanual palpation of the submandibular gland and the floor of the mouth. In case of parotid stones, palpation is much more difficult as a result of the anatomy of the duct system.

Imaging is crucial for exact localization of sialoliths. B-mode sonography, which is a non-invasive, commonly available and affordable procedure without any radiation or contrast dye, is the authors' imaging method of choice. Modern high-resolution transducers (7.5 MHz) detect stones with a diameter of 1.5 mm in 99.5% of cases. Furthermore, localization and number of stones can be determined accurately. Size and echogenicity of the affected gland may provide additional information about salivary gland function (Iro et al, 2000).

As a result of a higher anorganic component, submandibular stones are radio-opaque in 95% of cases, whereas only 60–70% of parotid stones can be detected by plain X-ray films.

Differential diagnosis of radio-opaque structures must include phleboliths, calcified haemangioma, lymph nodes and atherosclerotic plaques. Sialography is – apart from some special cases – of minor clinical importance nowadays. In the authors' population of more than 1400 patients, sialography was not necessary to establish a diagnosis in any case (Schwerk et al, 1985; Lomas et al, 1996).

Computed tomography (CT) and magnetic resonance imaging are dispensable for the diagnosis of sialolithiasis. Magnetic resonance sialography, an imaging method which visualizes sialoliths and ducts without contrast dye, should be restricted to special cases (Lomas et al, 1996).

Sialendoscopy with semi-rigid endoscopes is a useful diagnostic tool in the differential diagnosis of sialoliths, strictures and inflammatory changes of salivary ducts (*Figure 1*). It closes a diagnostic gap and may be important in establishing the need for resection rather than preservation of major salivary glands (Nahlieli and Naruchin, 1997; Katz, 1998; Marchal et al, 2002; Nahlieli et al, 2003; Zenk et al, 2004b).

Therapeutic strategies

A great number of different invasive, less invasive and minimally invasive therapeutic options are available for treatment of sialolithiasis. Localization and size of stones, as well as patients' complaints, complication rates and the attempt to rescue gland function are the basis for a differential therapeutic strategy.

Once the stone has been removed, impaired gland function as a result of prolonged congestion will completely recover in the majority of cases. Only symptomatic patients require treatment.

The paramount aim in the therapy of sialolithiasis is defined as 'living without stones', yet 'living without symptoms' may also count as success. For patients who are free of symptoms after therapy, but still have salivary stones, further treatment should be dependent on recurrence of clinical symptoms.

Treatment of acute suppurative sialadenitis in sialolithiasis

Anti-streptococcal and anti-staphylococcal antibiotics are the therapy of choice and should be administered intravenously in severe cases. Analgesics and decongestive drugs supplement pharmacological therapy. Furthermore the patient should regularly massage the gland in order to produce a continuous salivary flow. Abscess formation is an indication for immediate surgical intervention.

Conservative therapy, duct dilatation and basket extraction

Stimulation of secretion and regular gland massage are the basic therapeutic concepts in newly diagnosed sialadenitis with non-suppurative painful swelling. Dilatation of the ostium, which is the bottleneck of the duct system, often leads to a dramatic alleviation of symptoms or even complete removal of stones. Extraction of stones from the distal duct or the hilum of the parotid and submandibular gland can be achieved by dormia baskets (Brown et al, 2002). Conservative treatment concepts including basket extraction without endoscopic control result in a complete removal of stones in 10% of patients with submandibular and 20% with parotid duct sialoliths (Iro et al, 1998; Zenk et al, 2004b).

Figure 1. Sialendoscopic view of Wharton's duct. a. Distal duct. b. Hilum. c. Proximal to the hilum. Sialendoscopic view of sialoliths. d and e. Sialoliths of Wharton's duct. f. Sialolith of Stensen's duct.

Interventional sialendoscopy

Sialendoscopy for diagnostic measures was performed by Katz more than 10 years ago. The first trials with small flexible scopes started some years later – mostly for intracorporeal laser lithotripsy. Nowadays different semi-rigid systems are available. Together with integrated working and irrigation channels (diameter of 1.1–1.7 mm) and different microinstruments like baskets and grasping forceps, these instruments offer a maximum of safety and comfort for diagnostic and interventional procedures. It is even possible to reach some distance beyond the hilum into the smaller ducts within the submandibular and parotid ducts. The intervention can be carried out under local anaesthesia in most cases. In sialolithiasis the main indication for sialendoscopy – besides diagnosis of the concrement – is removal of the stone under direct view with an integrated instrument. In the authors' opinion, interventional sialendoscopy should be the treatment of choice of small concrements of the distal duct and hilum.

Duct slitting

Wharton's duct

Duct slitting can be performed under local anaesthesia in nearly all patients. Stones located in the anterior two thirds of the floor of the mouth can be removed without any complications (*Figure 2*). Solitary stones of the hilum can be completely removed in 96% of cases, and even multiple concrements in the hilum and the intraglandular duct system are removed in more than 60% of cases (Zenk et al, 2001).

Stensen's duct

As a result of the anatomy of Stensen's duct, duct slitting carries the risk of duct stenosis. This must also be considered for papillotomies, which are sometimes carried out to extract stones of the prepapillary region. The decisive factor for this complication is the size of the incision on the one hand and the function of the parotid gland on the other hand. Slitting of the parotid duct should be restricted to exceptional cases (Zenk et al, 1994; Iro et al, 1998).

Extracorporeal shock wave lithotripsy

Two different devices are available for extracorporeal shock wave lithotripsy (ESWL) of salivary stones: the piezoelectric system (Piezolith 2501, Richard Wolf Company, Knittlingen, Germany) and electromagnetic devices (Minilith, Storz Medical Company, Switzerland).

Coagulation disorders and acute sialadenitis are contraindications for ESWL.

Only patients who are very sensitive to pain receive oral analgesics before therapy. Children under 10 years of age require general anaesthesia. After sonographically controlled positioning of the concrement application of shock waves begins at the lowest possible intensity. Under continuous ultrasound control intensity increases until a maximum of 3000 (piezoelectric system) or 7500 shock waves (electromagnetic system) is reached. Usually three sessions at an interval of 4–12 weeks are necessary (Iro et al, 1992; Ottaviani et al, 1996; Yoshizaki et al, 1996; Katz et al, 1998; Escudier et al, 2003; Zenk et al, 2004a).

Once the salivary stones have been fragmentated, the calculi will probably leave the duct system naturally (*Figure 3*). This process can be supported by auxiliary measures: sialagogues and gland massage promote continuous salivary flow. Furthermore discharge of concrements can be facilitated by dilatation of the ostium. If fragments are palpable or detectable by sonography in the distal part of the duct system or near the ostium, extraction with a dormia basket is possible.

Mild swelling of the affected gland and petechial skin bleedings are reversible side effects of ESWL. Severe sialadenitis is rarely seen, abscess formation has not been observed after ESWL. Between 53 and 80% of patients with parotid stones are free of stones or symptoms after ESWL treatment (Iro et al, 1992, 1998; Ottaviani et al, 1996; Katz et al, 1998; Escudier et al, 2003). Relapses were not observed during a follow-up period of 6 years in the largest patient population that has been studied so far (Iro et al, 1998). In the authors' own long-term follow-up study, one third of patients with submandibular stones are free of stones, one third still have residual concrements, but are free of symptoms, and only one third needed additional treatment after ESWL (Zenk et al, 2004a).

Figure 2. a. Sonographic image of a right submandibular stone (+….+, 4.5 mm in diameter, echogenic reflex with posterior acoustic shadow) before duct slitting. GSM = submandibular gland, MM = mylohyoid muscle. b. No sialoliths are detectable on the sonographic view of the submandibular gland after duct slitting.

Intracorporeal shock wave lithotripsy

Different methods of intracorporeal endoscopically controlled lithotripsy have been described in the past few years. A decisive prerequisite for the implementation of these techniques was the availability of mini- and microendoscopes with suitable working channels.

After initial success, electrohydraulic and pneumatic lithotripsy have been abandoned because of side-effects like duct perforation and risk of nerve damage.

The Excimer laser (308 nm) is suitable for fragmentation in vitro, but at the expense of a high risk of tissue damage (Zenk et al, 1994; Iro et al, 1995). Complete removal of stones has been reported in 91.6% for the Excimer laser. The use of dye laser resulted in a complete fragmentation of stones in 40% of cases after 3–9 sessions. Dye laser with an integrated stone/tissue detection system lead to complete removal of stones in 46% after 1–3 treatment sessions (Ito and Baba, 1996).

Intracorporeal shock wave lithotripsy is of minor clinical importance in the treatment of sialolithiasis nowadays, as papillotomy is necessary in endoscopically controlled applications and the method is relatively time and resource consuming compared to the success rates.

Gland extirpation

Injuries of the lingual, hypoglossal and the mandibular branch of the facial nerve are risks of submandibular gland extirpation. The risk of injuring the latter nerve is described as between 6 and 18% in the literature (Lyall and Fleet, 1986).

Beides general anaesthesia, parotidectomy especially carries the risk of irreversible damage to the facial nerve in 7% of cases. Frey's syndrome (gustatory sweating, auriculotemporal syndrome) is subjectively noticeable in 10% of patients and objectively detectable in nearly all patients.

Surgical therapy of salivary stones should be restricted to cases where other treatment strategies have not been successful. Gland extirpation was necessary in less than 5% of cases in the authors' population of over 1400 patients.

Conclusions

Newly diagnosed sialolithiasis of the parotid and submandibular gland should be treated with conservative methods like sialagogues and gland massage for the first 3 months. At the same time interventional sialendoscopy should be attempted in order to remove the stone.

When treating parotid stones, because of the risk of duct stenosis, indication for papillotomy should be restricted to special cases. Duct slitting is not recommended because of the difficult anatomy of the parotid duct within the buccal soft tissue. If calculi cannot be removed by the measures described above, sonographically controlled ESWL is the method of choice independent of size and localization of the stones within the duct system. Gland extirpation should only be considered in special cases of multiple concrements (>three) or failure of ESWL (*Figure 4*).

Figure 3. a. Sonographic image of a left parotid stone (+…..+, 28.3 mm in diameter, echogenic reflex with posterior acoustic shadow) before extracorporeal shock wave lithotripsy (ESWL). MM = masseter muscle, UK = mandible, GP = parotid gland. b. Fragmented sialolith 1day after ESWL. UK = mandible. c. No sialoliths are detectable on the sonographic view of the parotid gland after ESWL. Note the hypoechoic region where the sialolith was formerly localized ('Steinbett').

Depending on localization and size of stones, the following differential treatment strategy has been proven to be successful if conservative treatment or interventional sialendoscopy have failed. For calculi of the distal duct and stones of the hilum and intraglandular duct system, which are detectable by enoral palpation, duct slitting is the method of choice. ESWL is recommended for stones

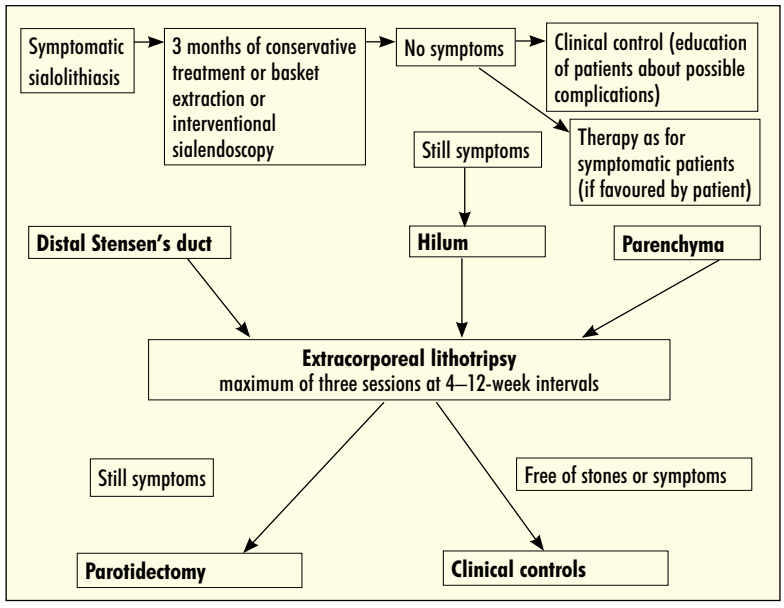

Figure 4. Treatment of parotid stones.

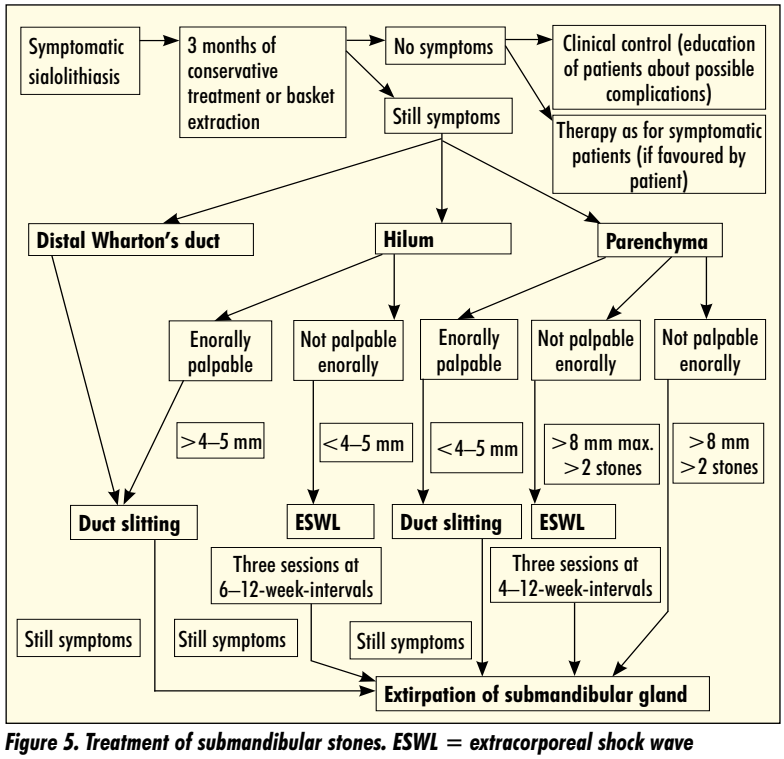

Figure 5. Treatment of submandibular stones. ESWL = extracorporeal shock wave lithotripsy.

KEY POINTS

- Sialolithiasis affects the submandibular gland in 80% and the parotid gland in 20% of cases (the incidence of symptomatic cases is 27.5–59 cases per million).
- High-resolution ultrasound and sialendoscopy are helpful tools in the diagnosis of salivary calculi.
- Nowadays, gland-preserving techniques like extracorporeal shock wave lithotripsy, basket extraction, interventional sialendoscopy and duct slitting are the treatment options of choice.
- Extirpation of the affected gland is necessary in less than 5% of cases today.

of the hilum and intraglandular duct system, which are smaller than 8 mm and not detectable by enoral palpation. For multiple sialoliths and stones of the duct system, which are larger than 8 mm, submandibulectomy is still the method of choice (*Figure 5*). **BJHM**

Conflict of interest: none.

Brown JE, Drage NA, Escudier MP, Wilson RF, McGurk (2002) Minimally invasive radiologically guided intervention for the treatment of salivary calculi. *Cardiovasc Intervent Radiol* **25**(5): 352–5

Escudier MP, McGurk M (1999) Symptomatic sialoadenitis and sialolithiasis in the English population, an estimate of the cost of hospital treatment. *Br Dent J* **186:** 463–6

Escudier MP, Brown JE, Drage NA, McGurk M (2003) Extracorporeal shockwave lithotripsy in the management of salivary calculi. *Br J Surg* **90:** 482–5

Iro H, Schneider Th, Födra C (1992) Shockwave lithotripsy of salivary duct stones. *Lancet* **339:** 1333–6

Iro H, Zenk J, Benzel W (1995) Laser lithotripsy of salivary duct stones. *Adv Otorhinolaryngol* **49:** 148–52

Iro H, Zenk J, Waldfahrer F, Benzel W, Schneider Th, Ell Ch (1998) Extracorporeal shock wave lithotripsy of parotid stones - results of a prospective clinical trial. *Ann Otol Rhinol Laryngol* **107:** 860–4

Iro H, Uttenweiler V, Zenk J (2000) *Kopf-Hals-Sonographie – Eine Anleitung zur praxisbezogenen Ultraschalluntersuchung.* [Head and neck sonography - A clinical guide to ultrasound examination.] 1st edn. Springer, Heidelberg

Ito H, Baba S (1996) Pulsed dye laser lithotripsy of submandibular gland salivary calculus. *J Laryngol Otol* **110:** 942–6

Katz P (1998) Nouvelle approche therapeutic des calculus salivaires: la lithotrypsie extra corporelle - A propos des 200 cases. [A new therapeutic approach for salivary calculi: extracorporeal shock wave lithotripsy - a study of 200 cases.] *Rev Stomatol Chir Maxillofac* **99** (Suppl 1): 109–11

Lomas DJ, Carroll NR, Johnson G (1996) MR sialography: work in progress. *Radiology* **200:** 129–33

Lustmann J, Regev E, Melamed Y (1990) Sialolithiasis. A survey on 245 patients and a review of the literature. *Int J Oral Maxillofac Surg* **19:** 135–8

Lyall JB, Fleet (1986) Morbity study of submandibular gland excision. *Ann R Coll Surg Engl* **68:** 327

Marchal F, Dulguerov P, Becker M, Barki G, Disant F, Lehmann W (2002) Submandibular diagnostic and interventional sialendoscopy: new procedure for ductal disorders. *Ann Otol Rhinol Laryngol* **111:** 27–35

Nahlieli O, Naruchin AM (1997) Sialoendoscopy: Three years' experience as a diagnostic and treatment modality. *J Oral Maxillofac Surg* **55:** 912–18

Nahlieli O, Shacham R, Bar T, Eliav E (2003) Endoscopic mechanical retrieval of sialoliths. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* **9:** 396–402

Ottaviani F, Cappacio P, Campi M, Ottaviani A (1996) Extracorporeal electromagnetic shock-wave lithotripsy for salivary gland stones. *Laryngoscope* **106:** 761–4

Schwerk WB, Schroeder HG, Eichhorn T (1985) Hochauflösende real-time Sonographie bei Speicheldrüsenerkrankungen. I Entzündliche Erkrankungen. [High-resolution real-time sonography in diseases of the salivary glands. I: Inflammatory disorders.] *HNO* **33:** 505–10

Yoshizaki T, Maruyama Y, Wakasa R, Motoi I, Furukawa M (1996) Clinical Evaluation of extracorporeal shock wave lithotripsy for salivary stones. *Ann Otol Rhinol Laryngol* **105:** 63–7

Zenk J, Benzel W, Iro H (1994) New modalities in the management of human sialolithiasis. *MIT* **3:** 275–84

Zenk J, Constantinidis J, Kydles S, Hornung J, Iro H (1999) Klinische und diagnostische Befunde bei der Sialolithiasis. [Clinical and diagnostic findings in sialolithiasis.] *HNO* **47:** 963–9

Zenk J, Constantinidis J, Al-Kadah B, Iro H (2001) Transoral removal of submandibular stones. *Arch Otolaryngol Head Neck Surg* **124:** 432–6

Zenk J, Bozzato A, Winter M, Gottwald F, Iro H (2004a) Extracorporeal shock wave lithotripsy of submandibular stones: evaluation after 10 years. *Ann Otol Rhinol Laryngol* **113:** 378–83

Zenk J, Koch M, Bozzato A, Iro H (2004b) Sialoscopy - initial experiences with a new endoscope. *Br J Oral Maxillofac Surg* **42:** 293–8