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Review

Thirty years of experience and current trends in the management of sialolithiasis: a narrative review

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Abstract

Current trends in the management of sialolithiasis include a proper diagnosis with the help of a differential diagnosis. Cone beam computed tomography may be a good choice for detecting sialoliths because it is more sensitive than sonography. A practitioner should collect precise information about the stone in question, which includes the exact location of the calculus, its size and volume, and the number of calculi in a given case. For submandibular calculi, the orientation of the stone's location against the gonion and the inferior edge of the mandible creates the system of coordinates almost in a geographical fashion. The next step is management planning, and a proper surgical approach may be selected from a comprehensive list of available techniques. If the sialoendoscopic removal of calculi via ducts is impossible, endoscopy-assisted, ultrasound (US)-guided, or unassisted intraoral surgery, extracorporeal shock-wave lithotripsy (ESWL), a combination of the ESWL with the sialoendoscopy, and endoscopy-assisted ductal stretching procedure are our options. Measures must be taken to avoid or minimise postsurgical complications. The development of our knowledge, skills, diagnostic arsenal, and surgical approaches to sialolithiasis cases over the last hundred years is impressive. However, there is still room for further improvement. Some problems in diagnostics, calculus assessment, and surgical approaches require additional research.

Keywords: sialolithiasis; salivary glands; sialoendoscopy; calculi

Introduction

In 1926, Harrison collected 375 published cases of the salivary gland calculi (1825–1925), added 27 of his cases, and analysed 402 patients with sialolithiasis.[1] Today, a similar number of cases can be presented in one article. In 1932, Ivy and Curtis reported 96 cases of sialolithiasis collected in 11 years.[2] Currently, practitioners can collect the same number of cases in one year. A reported incidence of sialolithiasis varies from 1 in 10,000 to 1 in 30,000.[3] Adding 30 years of experience to this historical perspective, current trends in managing sialolithiasis include a proper diagnosis, precise information about the stone in question, which provides its exact location, size, volume, and the number of calculi in a given case, and management planning. A proper surgical approach may be selected from several available techniques. Measures must be taken to avoid or minimise postsurgical complications. These objectives will be the topics of the current review.

Diagnosis

Physical examination may be sufficient in cases with larger stones in the distal part of the submandibular duct. Smaller stones within the submandibular or parotid duct or in the gland's parenchyma require imaging techniques for their detection. In the 19th century, surgeons localised a stone by inserting 'a small silver probe into the duct.'[4] Current imaging armamentarium includes point-of-care ultrasonography (US), rarely used conventional radiography and sialography, various types of computed tomography (CT), and direct

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sialoendoscopic visualisation. This armamentarium is not yet ideal. Conventional radiography was ruled out because 20% of calculi are not radio-opaque.[2,5] Sialography requires an improved contrast injection technique.[6] US cannot detect small stones and calculi obscured by the shadow of the mandible.[7,8] Magnetic resonance imaging (MRI) experiences difficulty detecting stones because a stone may be presented as a filling defect in T2-weighted MRI images. Sialoendoscopy visualises a stone in a duct, but in cases of multiple stones, deeper-located stones can be observed during the surgery. Non-contrast and contrast-enhanced CT have demonstrated impressive sensitivity and specificity.[9,10] False-positive results are possible if the injected contrast media mimics a stone or dental fillings, implants, and permanent dentures cause metallic artifacts.[7,11]

Cone beam computed tomography (CBCT), defined as 'X-ray microtomography of bones and teeth,'[12] is a good choice for detecting sialoliths. It is more sensitive than sonography and is used in cases of complex sialolithiasis that traditional imaging methods cannot diagnose.[13,14] Its sensitivity (94%), specificity (90%), positive predictive value (84%), and negative predictive value (97%) with an overall accuracy of 92% is impressive.[15] Sialography may be combined with CBCT (sialo-CBCT).[16] CBCT and its three-dimensional reconstructions provide an excellent resolution with minimum irradiation and interference from a dental crown bridge and fillings.[17,18] (Figs. 1, 2)

The differential diagnosis for unilateral gland swelling includes cellulitis, inflammatory or infectious sialadenitis, dental abscess formation, neoplasm, masticator space infection, lymph node metastasis, and recurrent parotitis.[19] Clinical diagnosis of sialolithiasis can be challenging because patients with asymptomatic calculi present symptoms only when a stone obstructs the ducts, and a practitioner deals with sialolithiasis and sialadenitis simultaneously. A patient may experience painful mastication, and temporomandibular joint disorders should also be considered. Salivary gland tumours rarely mimic sialadenitis and stones. CBCT is helpful in such differential diagnosis.

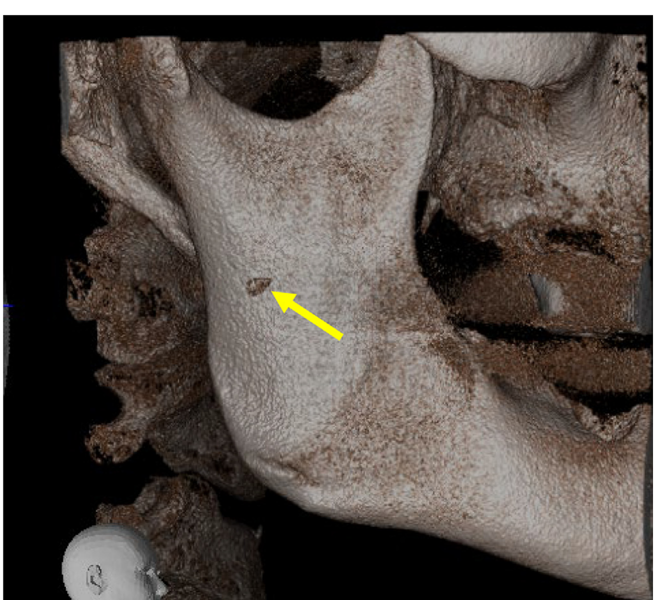

Fig. 1. Three-dimensional cone-beam computed tomographic reconstruction of stone in the right parotid gland (yellow arrow).

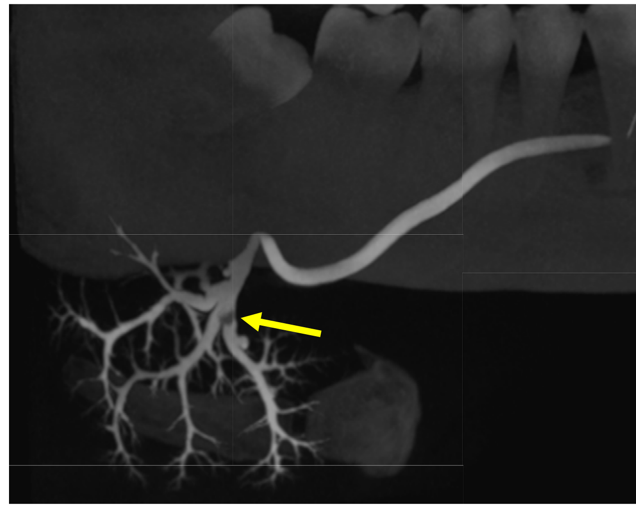

Fig. 2. Cone-beam computed tomographic sialogram demonstrates the exact location of the stone (yellow arrow) in the hilum of the gland.

The stone

Calculi are variable in shape and size, with the longest diameter ranging from 2.1 to 10 mm, sometimes reaching 15 mm.[9,19,20] Submandibular stones are generally larger than parotid calculi. The precise identification of the location and size of the calculi has a significant impact on choosing the approach for their removal. Measuring the longest diameter of the stone is not enough. I recommend measuring the stone dimensions in the anterior-posterior vertical, lateral horizontal, and inferior-superior horizontal planes. The volume of the stone may be calculated using non-invasive volume estimation techniques.[21,22]

Knowing the stone's precise location is equally as important as knowing its size and volume. Various landmarks are used to analyse CT and MRI images for localisation of the parotid neoplasms.[23] The same approach can be used in cases of gland parenchyma sialolithiasis. Such landmarks are not yet designed for the submandibular gland, except for the stone's position against the mandible.[24] The orientation of the stone's location against the gonion and the inferior edge of the mandible may create the system of coordinates almost in a geographical fashion. Measuring the shortest distance from the stone to the unilateral gonion helps assess how deep the parenchyma-located stone. These parameters of the size and position of the calculi using CBCT and CBCT images 3D reconstructions [25] are effective for evaluating the complexity of the surgery. If a calculus was located in the primary submandibular duct, its volume, the dimension in the inferior-superior vertical plane, and the shortest distance between it and the inferior border of the mandible would influence surgical planning. For CBCT-detected impalpable submandibular calculi, the stone's in-depth location against the inferior border of the mandible is the primary important variable. For calculi located in the secondary submandibular duct or parenchyma, the knowledge of their volume, position against the edge of the mandible, and the shortest distance from the stone to the unilateral gonion will help choose the appropriate surgical removal technique. The first step in surgical planning is the bimanual palpation of the submandibular stone. Palpable and mobile stones and fixed or unpalpable stones require different approaches.

Treatment

Several decades ago, minimally invasive surgery was praised as a novelty in sialolithiasis management. The fact that a submandibular stone was removed 'through the natural orifice, with a probe and pair of fine forceps' in 1871[26] adds some modesty to our current position. Yet, when sialendoscopy was introduced to the surgeon's armamentarium for diagnosing and managing sialolithiasis in the 1990s, it was a significant step towards improving minimally invasive techniques. The advantages and disadvantages of sialendoscopy were described in detail.[27–30] Acute sialadenitis is the only absolute contraindication to this intervention. Relative contraindications include multiple stones or stones in the gland that cannot be reached endoscopically or via surgery.

The diameter of Wharton's duct is 1.45–1.51 mm (orifice: 0.49 mm), and the diameter of Stensen's duct varies between 1.22 and 1.42 mm (orifice: 0.52 mm).[9,30] The inflation with saline expands the elastic duct, and forceps and basket-equipped endoscopy may remove mobile calculi with a diameter less than 5 mm and, sometimes, 7 mm. (Fig. 3) If the direct sialoendoscopic removal of calculi is impossible, we apply endoscopy-assisted, US-guided, or unassisted intraoral surgery, extracorporeal shock-wave lithotripsy (ESWL), a combination of the ESWL with the sialoendoscopy, and endoscopy-assisted ductal stretching.[9,19,29–31] Gland excision is our last choice. Surgeons appreciate intraoperative endoscopy to determine the exact location of calculus, follow its removal to visualise pathological changes in the salivary duct system (strictures), and detect additional calculi.

Fig. 3. Removal of a submandibular stone with mini-forceps.

Surgery planning starts with assessing the ducts and orifices. The parotid duct orifice can be found on the contact surface between the maxillary first and second molars about 7 mm above a line touching the buccal cusps of the upper molars. Still, its position can move up to 1 cm in any direction.[32] The masseteric bend of Stensen's duct presents a problem for sialoendoscopy because its angle varies from 100 to 130° during the manipulation.[32] The long Wharton's duct presents the orifice located on the frenulum or close to the frenulum of the tongue.[33] An experienced practitioner could overcome these complications by introducing the endoscope through a papillotomy procedure or with the help of lacrimal probes and ductal dilators. The individual anatomy of the ducts should be inspected before endoscopic intervention is planned.

Large posterior sialoliths connected to the ductal walls, calculi located in the posterior part of the salivary ducts, hilum, and parenchyma require the intraoral surgical approach.[9] Following our historical perspective approach, 'an incision at the side of the tongue permitted the release of two salivary calculi' in 1865.[34] What was suitable for superficially located palpable stones in the 19th century can be performed now for submandibular and parotid stones of almost any location. It highlights the necessity of a careful CBCT-based assessment of the deep versus superficial position of the calculus against the floor of the mouth in submandibular cases. If a deep stone is located close to the body of the mandible, the mylohyoid ridge may become an obstacle to bypass. Specifically, calculus may be challenging to approach if it is located in the submandibular fossa below the Mylohyoid line and Mylohyoid groove.

Ductal stretching is an intraoral technique that helps overcome calculus removal, which cannot be solved with pure interventional endoscopy.[9,31] It involves an incision above the involved duct, stretching the duct forward with a fine haemostat, sialolithotomy, and stent insertion. Endoscopy assistance is needed to determine the exact location of the stone, remove additional calculi, the stone's attachments to the duct, dilatation of strictures, lavage to remove mucous plaques and debris, and insert a salivary stent. Ductal stretching is a suitable method for removing posterior and hilar stones. Similar techniques were described by McGurk and Zenk et al[29,35] (Fig. 4).

While the endoscopy technique preserves the integrity of the ducts, intraoral surgery requires long or short transoral duct slitting and subsequent restoration of the duct, preferably by a stent. The stent may produce a new orifice of the duct closer to the gland. It is physiologically possible because the duct orifices are not sphincters. The shortened Wharton's duct with the newly created orifice reduces the recurrence rate for sialolithiasis but does not affect the rate of postsurgical complications.[36] It is essential to use stents following every endoscopic surgical intervention in the glands, especially after dissecting the salivary orifice, to prevent duct obstruction, atrophy of the gland, and swelling.[9,28]

ESWL was introduced as a reliable and safe technique that does not require sedation.[9] Three sessions of ESWL treatment can be administered at one-month intervals. Dis-

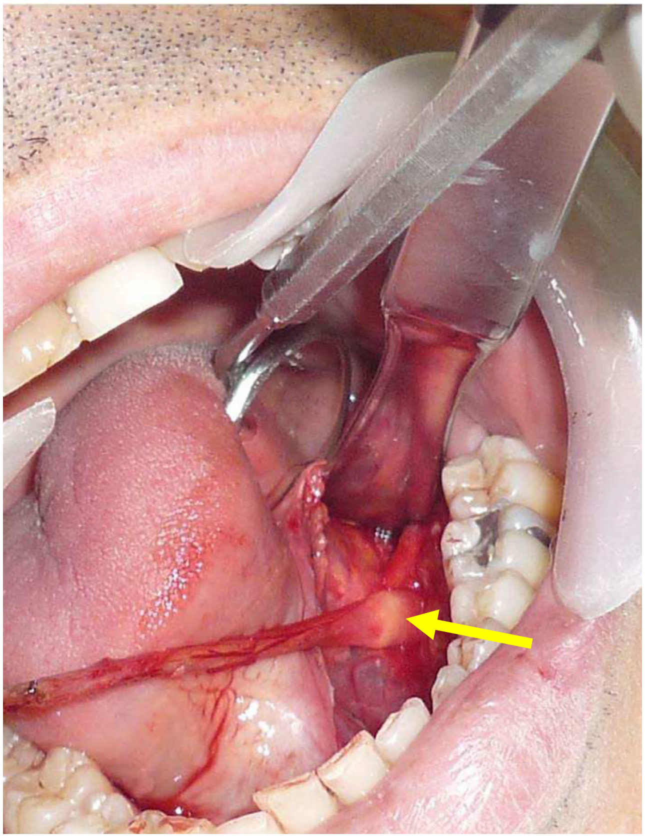

Fig. 4. The 7 mm stone is located in the hilum of the left submandibular gland. In this case, the stretching procedure (yellow arrow directed to the stone) was used.

connecting the outer cortex of the stone during/after lithotripsy and the positive impact on scar tissue allow saliva leakage to the oral cavity, bypassing calculus. ESWL cannot fragment all the stones and remove all the fragments from the ducts. Some reports indicated a high complication rate among paediatric patients.[37] Efforts were made to replace ESWL with intraductal shock-wave lithotripsy (ISWL), with its pneumatic, electrohydraulic, and electrokinetic variations, and Holmium:YAG laser-assisted intraductal sialendoscopic lithotripsy. To date, all these methods require an additional assessment to be recommended.[38] From my experience, ESWL can be effectively used, but only in low-energy mode. The ESWL + the intraductal or extraductal endoscopic approach requires careful patient selection. For the submandibular calculi, the best cases are small (<5 mm) calculi in secondary ducts, parenchyma, or fixed in the main duct or the hilum, and medium to large (>5 mm) hilar or intraglandular immobile stones attached to the surrounding tissue.[9] For the parotid calculi, cases with stones of a similar size located in the middle third of the duct and proximally are convenient for the combination of ESWL and endoscopy.

Parotid stones from the middle part of Stensen's duct and proximal to the gland that cannot be removed endoscopically present a challenging intervention for the practitioner. In 2002, Nahlieli presented a combined transfacial approach for them. (Figs. 5 and 6) The technique uses the sialendoscope to locate the stone, using the transillumination effect and an endoscopic view. The stone is removed using an external transracial approach via a rhytidectomy incision.[39]

Complications

There are general complications (bleeding, infection), site-specific complications (damaging various facial nerves), and endoscopy-specific complications. The endoscopy-related complications are rare (2%–3% of cases) and include avulsion of the salivary duct, postoperative strictures, gland swelling, salivary fistulas and perforations (false route), traumatic ranulas, and lingual nerve paraesthesia.[19,28] Postoperative strictures are the most frequent complication both in the parotid and the submandibular cases.[9] Most strictures are near the duct orifice, and successful dilation is possible. The duct perforation occurs near the orifice because of the separation of the ductal wall from the oral mucosa during endoscopic manipulations such as stone removal and stricture dilation. Current improvements in the practitioners' skills and the quality of endoscopic armamentarium made this complication very rare and mainly found in paediatric cases.[37]

Ranula and lingual nerve paraesthesia are well-documented outcomes of surgical interventions on the floor of the mouth, endoscopy-assisted or otherwise.[9] Formation of ranula can occur in patients following submandibular sialendoscopy or intraoral surgery and is proportional to the extent of the procedure. Ranula is easily identified by blue swelling on the oral cavity floor and is subject to successful marsupialisation. To prevent this complication, I recommend using a stent and adding a Penrose drain in the sublingual area when dissecting the sublingual region. Lingual nerve paraesthesia can complicate any surgical intervention on the floor of the mouth. This complication usually occurs during surgical manipulation around the proximal part of the Wharton's duct.[40] If the nerve is damaged, steroid treatment

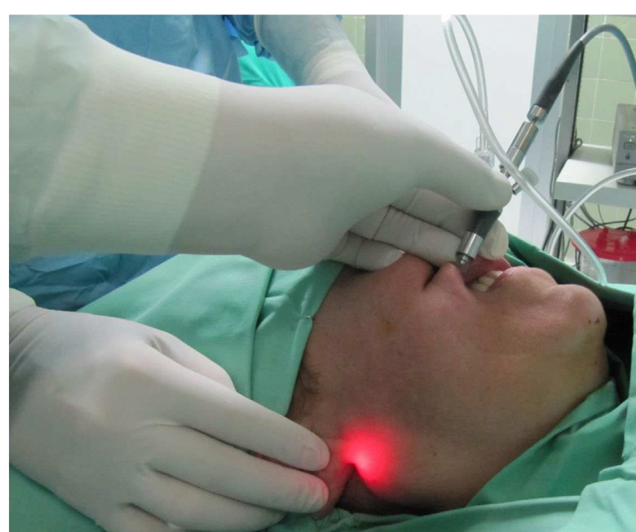

Fig. 5. In the transfacial approach for parotid stone, the transillumination assists in the location of the stone.

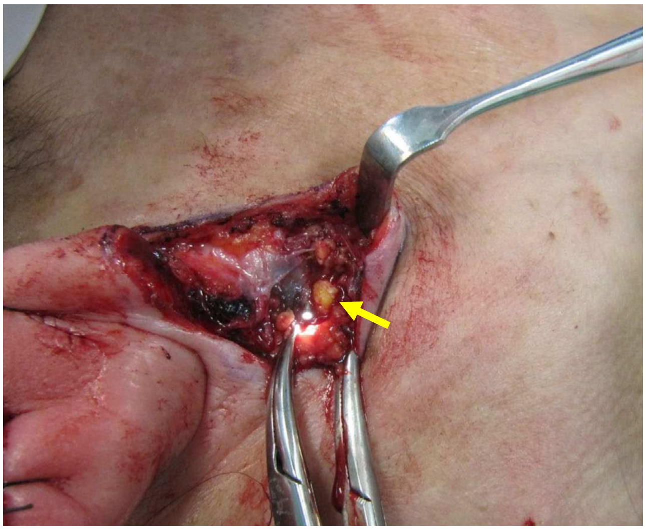

Fig. 6. Removal of the stone (yellow arrow) followed the transillumination for the stone location via the preauricular approach.

should be administered immediately. Changing paraesthesia into anaesthesia is very rare. Salivary fistulas, sialoceles, minor ductal tears, minor bleeding, and acute masseteric bend in parotid cases, while reported, are infrequent.[9,39,40] Most complications of parotid surgery are of neurological matter and include facial palsy/paralysis or Frey's syndrome. These complications occur during an open surgery and were not documented for endoscopic procedures.[9,40]

While the development of our knowledge, skills, diagnostic arsenal, and surgical approaches to sialolithiasis cases over the last hundred years is impressive, there is still room for further improvement. Some problems in diagnostics, calculus assessment, and surgical approaches require additional research. To add just one, the chemical composition of calculi varies, but we cannot assess it until a calculus is removed. We cannot employ fine needle aspiration as in tumour cases. The chemical composition question is practical because predominantly calcium phosphate-composed and predominantly protein-composed calculi might react differently to ESWL/ISWL interventions. Calcium phosphate-composed calculi are less mobile inside a duct, which could be considered during surgery planning if we knew the chemical composition of the stone in question. Our field for further research remains wide!

Conflict of interest

I have no conflicts of interest.

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Ethics statement/confirmation of patient permission

Not required.

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