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INTRODUCTION
Sialolithiasis is the most frequent nonneoplastic obstructive disease of the major salivary glands, being responsible for 60% to 70% of all obstructive salivary gland disorders.1 Between 5% and 20% of all salivary stones are found in the parotid gland,2 where they may remain clinically undetected for a long time or cause recurrent gland swelling and pain.

Conventional sialography investigations of the morphology of the salivary gland duct system have recently been replaced by more precise and noninvasive radiological approaches, and diagnosis is now based on color Doppler ultrasonography (US), cone-beam 3D computed tomography (CBCT), and magnetic resonance sialography.3 Treatment depends on the exact location and size of the stone.4 Traditional surgical procedures such as partial or complete gland removal have now been abandoned in favor of minimally invasive approaches. Interventional sialendoscopy has proved to be highly effective in the case of stones that are smaller than 4 mm, as with extracorporeal shockwave lithotripsy (ESWL) in the case of stones of greater size.1,4–6 Palpable stones of more than 7 mm (especially if impacted or after the failure of noninvasive techniques) are amenable to sialendoscopy-assisted transfacial removal.1,4,5,7–9

However, deep parenchymal stones may be difficult to be endoscopically located due to Stensen duct strictures or kinking that may possibly prevent sialendoscopy progression. Carroll et al. have proposed using intraoperative US as a guide to overcome this challenge.10 An alternative means of detecting a stone is intraoperative CT navigation, which currently is primarily used for sinus and skull base surgery.11

We here describe a variation of the traditional transfacial approach to removing a nonpalpable parotid parenchymal stone embedded into the ductal system that involves the assistance of CT navigation and sialendoscopy.

MATERIALS AND METHODS
A 66-year-old female patient was referred to the University of Milan’s Department of Otolaryngology and Head and Neck Surgery due to the recurrence of painful left facial swelling. After the patient’s history were recorded in detail, the parotid region was carefully evaluated visually and by means of palpation without any causes of salivary obstruction being detected. A subsequent US assessment of the region using a 7.5 MHz Hitachi H21 scanner (Hitachi High-Technology Corporation Ltd., Tokyo, Japan) identified a 6-mm parenchymal stone in the left parotid gland, and a CT scan was used to confirm the location and size of the stone (GE Lightspeed 64 Slice CT scanner, GE Medical Systems, Waukesha, WI). The depth of the stone prompted the decision to adopt a navigation- and sialendoscopy-assisted transfacial approach to its removal; therefore, before surgery the patient’s digital imaging and communications in medicine dataset (DICOM) was uploaded to set up the optical-based navigation system of the operating room (Brainlab, Munich, Germany).

At the time of surgery, which was performed under general anesthesia, a registration pointer was used to locate the surface points on the skin of the maxilla to obtain an automatic match with the uploaded data. Multi-planar CT reconstruction images were displayed in real time on a drapeable display to track the navigation pointer. A salivary probe (Bohman probes, Karl Storz, Tuttingen, Germany) was used to widen the orifice of the Stensen duct, and a flexible semirigid sialendoscope (0.8 mm, Karl Storz) was used to visualize the ductal system. The endoscope was easily pushed through the main duct and its branches under constant irrigation with saline solution until the impacted stone was partially visualized into a secondary branch, beyond a duct kinking, not adequately accessible for interventional sialendoscopy; the endoscope was then retracted.

After preparing the surgical field, the stone was located intraoperatively by means of the navigation pointer, and a corresponding landmark was drawn on the skin (Fig. 1). A preauricular skin incision was made, and a skin flap was raised to expose the parotid gland. The stone was precisely identified inside the gland parenchyma by means of direct visualization on the display (Fig. 2). A blunt dissection was performed until the Stensen duct...
was identified and exposed for 1 to 2 cm of its length (Fig. 3). A neurostimulator (Neuro-Pulse, Bovie Medical Corporation, Clearwater, FL) was used to check the functioning of the branches of the VII cranial nerve during dissection. The sialendoscope unit was reintroduced into the duct system to reach the exact position of the stone and verify the correspondence between the sialendoscopic light and the landmark of the navigation pointer. An incision was made in the parenchyma over the secondary duct branch under navigation guidance, and the stone was removed using blunt instruments. The lumen was flushed with saline solution to eliminate any residual stone debris as the endoscope explored the lumen in the area of incision; the duct wall was sutured using a 6-0 polyglactin stitch (Vicryl, Johnson & Johnson International, Brussels, Belgium); a hemostatic patch (Tabotam, Ethicon Sarl, Neuchatel, Switzerland) was placed over the duct; and the parotid fascia and skin incision was closed.

Antibiotic prophylaxis was given perioperatively and continued during the hospital stay. A liquid diet was started after 48 hours of fasting, and a pressure dressing was applied for 72 hours. The patient was discharged after 5 days and clinically re-examined after 1 week and again after 1, 3, and 6 months, when a final US assessment was also made.

RESULTS

A 6-mm nonpalpable salivary stone that was embedded into the secondary branch of the left Stensen duct was successfully removed using a CT navigation- and sialendoscopy-assisted transfacial approach. The duration of surgery was comparable with that of traditional transfacial procedures. No further surgery was required as the stone was completely removed, and no residual debris remained in the duct system. No major or minor complication (i.e., facial nerve palsy, sialocele, salivary fistula, sialadenitis) occurred during or after the procedure; postoperative mild gland swelling resolved in a few days with the application of a pressure dressing. The scar was minimal (Fig. 4).

Clear salivary flow was flushed out from the main parotid duct at the times of the follow-up clinical evaluations, and a US examination 6 months after surgery revealed restored salivary flow with no residual stones or duct dilation.

DISCUSSION

Many articles have been published concerning the use of transfacial surgery to treat impacted and palpable parotid ductal or parenchymal stones of greater than 7 mm,1,3,4,12 and its efficacy has been validated in various studies.2,5,13–16 It relies on intraoperative (usually sialendoscopic) stone detection, and the external surgical incision is guided by manual palpation and transillumination during the endoscopic procedure.8,10,12 The technique has been proposed as a valid alternative to ESWL (US-monitored stone fragmentation by means of shockwaves), which has been considered an efficient means of treating all parotid stones, particularly intermediate 4 to 7 mm stones.1,4,17 However, ESWL is not only influenced by stone size but also by the possibility that residual stones remain in the duct system and the fact that only a few
dedicated centers have acquired significant experience in its use. Nevertheless, the management of deep and non-palpable parotid parenchymal stones is still based on ESWL or traditional parotidectomy.

We successfully used CT navigation- and sialendoscopy-assisted transfacial approach to remove a parotid stone that could not be identified by means of palpation. To the best of our knowledge, this is the first report of an extraoral approach to parotid sialolithiasis using navigation surgery in association with sialendoscopy. Navigation is already used in sinus and skull base surgery, for which the precision of optical systems is high and the deviation under clinical conditions is about 2 mm.

Computed tomography evidence of a highly impacted parotid stone allowed us to set up a navigation system for the intraoperative anatomical orientation of soft tissues and evaluate the depth of the stone from the skin surface.

Computed tomography and CBCT seem to be optimal radiological imaging techniques for detecting sialolithiasis, with the latter having the advantage of a lower radiation dose. In the case of parotid stones, the 93% specificity and 94% sensitivity are higher than those of US, although extensive scattering due to the presence of dental restorations or a radiolucent stone can hamper diagnosis. We usually prefer CBCT for studying sialolithiasis; however, in this case we used a simple CT scan to obtain data that could be used by the navigation system.

In comparison with intraoperative US guidance, CT assistance has a great sensitivity and is much more easily to be interpreted, but it must be considered that CT scan image guidance does not provide real-time images. It thus should be reserved for immobile stones, and a method of confirmation of stone location such as scope could be useful at the time of surgery. Ultrasonography guidance provides real-time images, does not expose the patient to ionizing radiation or require intraoperative scope verification, and is less expensive than CT. However, it is less sensitive and is an operator-dependent tool.

There was an excellent match between the external navigation and sialendoscopic transillumination when localizing the stone, and navigation allowed us to perform minimally invasive surgery without damaging the facial nerve and without running the risks of superficial parotidectomy with reduced likelihood of temporary or permanent facial paralysis.

No postoperative salivary fistula or sialocele occurred, and salivary flow was reestablished within a few days because sparing the gland parenchyma allows restoration of salivary gland flow and function even in the case of chronic obstructive sialadenitis.

**CONCLUSION**

The sialendoscopy-assisted transfacial approach is a less invasive option than superficial parotidectomy for the treatment of palpable and impacted parotid ductal or parenchymal stones greater than 7 mm.

Although CT navigation means more technical efforts and costs, as well as radiation for the patient, the combined CT and sialendoscopy-assisted approach is an acceptable solution for deep intraparenchymal, nonpalpable, and impacted parotid stones, especially those smaller than 7 mm, which cannot be seen or reached by interventional sialendoscopy. In all other situations, stones can be managed by means of interventional sialendoscopy with intraoral lithotripsy, ESWL, or sialendoscopy-assisted surgery.

Although our findings need to be validated in a series of patients, they do show that the combination of CT navigation and sialendoscopy can guide surgery even in the case of deep, immobile, and impalpable parotid stones traditionally managed by ESWL or parotidectomy.

**BIBLIOGRAPHY**


