Use of Cone-Beam Computed Tomography in Performing Submandibular Sialolithotomy

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Purpose: Sialolithotomy for submandibular gland lithiasis is a common procedure often performed in the office setting, with the patient under local anesthesia. The location, size, and number of the sialoliths can greatly influence the indication owing to the difficulty of the procedure for hilar and proximal calculi. The purpose of the present study was to report our experience regarding the advantages of using preoperative cone-beam computed tomography (CBCT) to evaluate submandibular gland lithiasis in patients undergoing sialolithotomy for calculi located anywhere in the area of Wharton's duct, with special regard to hilar and proximal calculi.

Materials and Methods: We performed a retrospective study by reviewing the medical records of patients with a diagnosis of sialolithiasis of the submandibular gland using CBCT performed the day of stone removal by sialolithotomy. We have described the operative technique and the CBCT landmarks used for intraoperative orientation and control.

Results: Thirty-two patients with submandibular sialolithiasis were included in the present study. A total of 51 salivary stones were identified using CBCT. Proximal and hilar calculi were encountered in 14 cases. The number of calculi diagnosed using CBCT matched the number of surgically removed calculi in all cases. Transient lingual nerve hypoesthesia was encountered in 2 patients. No obstructive symptoms recurred after surgery.

Conclusions: We found that preoperative CBCT allows for an optimal understanding of the individual stone configuration in relation to the patient's anatomy. It allows for easy identification of the calculi during sialolithotomy, leading to greater confidence in approaching proximal and hilar stones.

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A routine encounter in maxillofacial practice, sialolithiasis stands for most salivary gland disorders. Anatomic, topographic, and functional factors contribute to the predominant formation of sialoliths in the submandibular glandular structures in more than 80% of cases, mainly in the ductal system and more often in the proximal section of the duct or hilar area.[1-4]

Preservation of the submandibular gland is important for maintaining the fullness and normal contour of the submandibular area and to avoid injury to several adjacent nerves. This concept has become

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increasingly accepted, since several studies have shown that glandular function will be regained after removal of the salivary stone, with few cases of recurrent lithiasis or complications.[5,6]

The intraoral extraction of sialoliths can be achieved by sialolithotomy, a technique that avoids the high costs and long learning curve necessary for endoscopic procedures and can be performed within a shorter operating time. Although frequently performed for distally located calculi, the removal of more proximal and hilar sialoliths presents with some technical challenges, especially when the calculi are not detectable by bimanual palpation. These are the main reasons many surgeons have continued to perform submaxillectomy in such cases. Approximately two thirds of submandibular sialoliths will be located in the proximal part of the duct and infundibulum.[2,4] With such a high frequency, it is important to develop widely accessible techniques to help increase the confidence of surgeons in approaching these calculi by an intraoral route and preserving the submandibular gland.

The purpose of the present study was to report our experience regarding the intraoral removal of salivary calculi using sialolithotomy, performed with the patient under local anesthesia as an office-based procedure, for both palpable and nonpalpable sialoliths. We have described the use of cone-beam computed tomography (CBCT) performed the day of surgery, which helped increase confidence in approaching difficult cases using the intraoral route and led to the predictable removal of all detected calculi within a short operative time.

Materials and Methods

Owing to the retrospective nature of the present study, it was exempt from institutional review board approval. We followed the guidelines of the Declaration of Helsinki during the entire research process.

PATIENTS

We performed a retrospective medical record review of all patients with submandibular sialolithiasis who had undergone sialolithotomy from January 2015 to January 2018. We only included adult patients who had undergone evaluation with the help of CBCT performed the day of surgery and had a minimum of 12 months of follow-up. We selected the patients who had no history of previous surgery in the area. Only patients without an indication for submandibular gland removal were included in the present study. Patients who had undergone sialolithotomy for an acute obstructive episode due to ductal lithiasis but with a diagnosis of additional intraparenchymatous calculi were scheduled for submaxillectomy 1 month after the acute episode and were therefore excluded from the present study.

CBCT EVALUATION

CBCT was performed the day of surgery for all patients. The scanning field included the whole mandible (including the complete vertical branches) and the hyoid bone to ensure visualization of the entire submandibular gland area. The presence of concurrent parotid gland lithiasis could also be evaluated using this volume. Images were analyzed with the help of dedicated software (RadiAnt DICOM [Digital Imaging and Communications in Medicine] viewer [Medixant, Poznan, Poland] and Osirix DICOM viewer [Pixmeo SARL, Geneva, Switzerland]). A multiple panel view was used for comparison and measuring. Three-dimensional image reconstruction was performed for an enhanced understanding of the anatomy and the relationship with the surrounding structures. The number, location, and dimensions (largest length, width, and height) of the salivary calculi and the approximate shape were documented.

The landmarks for the position of the calculi were determined. Most often, the ipsilateral mandibular teeth were used for orientation of the distal, middle, and proximal ductal calculi. In the absence of the ipsilateral mandibular teeth, the contralateral mandibular teeth can be used or, even, the maxillary teeth, although less precise, with consideration of the approximate relationship between the dental arches when CBCT was performed. In an edentulous patient, the distance can be measured from the midline to a horizontal line passing through the sialolith. Determination of the position of the salivary stone in relation to the mental foramen can also be of help. For hilar calculi, one should determine the approximate position in relation to the anterior and posterior borders of the vertical mandibular ramus, in particular, how far behind the anterior mandibular border. To approximate the depth, the occlusal plane of the mandibular teeth or the alveolar crest plane in edentulous patients and the basilar border of the mandible will serve as useful landmarks. The mylohyoid line is another useful structure for determining the position of the hilum and hilar calculi.

The landmarks used for orientation have been illustrated with the help of CBCT images from 4 patients with a diagnosis of submandibular sialolithiasis who had undergone sialolithotomy on the same day (Figs 1 to 16).

SURGICAL TECHNIQUE

Sialolithotomy was performed with the patient seated in the dental chair under local anesthesia. Local anesthesia consisted of a lingual nerve block

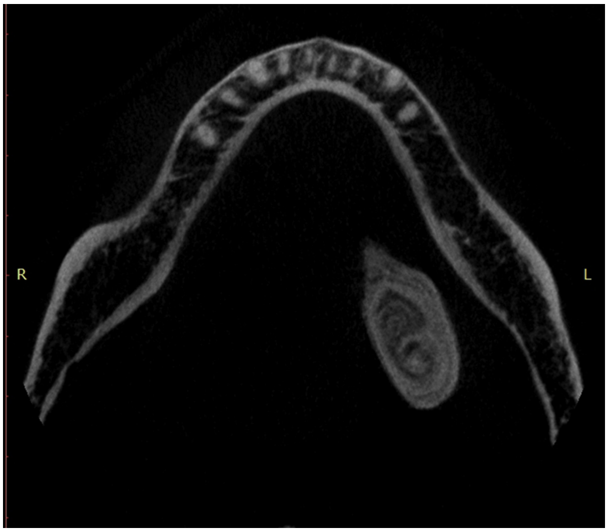

FIGURE 1. Patient 1. Cone-beam computed tomography image, transverse sectional view, of a patient with a megalith located at the level of the left submandibular gland infundibulum. In this patient, the size of the calculus rendered it easy to find intraoperatively; however, the shape and dimensions are also important to allow for the reconstitution of the stone in the case of fragmentation and to ensure complete removal.

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completed by local infiltration of small quantities of anesthetic with a vasoconstrictor in the floor of the mouth. Mild sedation was achieved by preoperative

FIGURE 2. Patient 1. Cone-beam computed tomography image, 3-dimensional superior view. On the 3-dimensional reconstruction, the maxillary bone, cervical spine, and hyoid bone were cropped, as was part of the contralateral mandible in the lateral view, to allow for an enhanced view of the sialolith's shape. Thus, the calculus can be observed from multiple angles for a better understanding of its form and the spatial relationship with the regional anatomic landmarks.

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FIGURE 3. Patient 1. Cone-beam computed tomography image, 3-dimensional posterior view.

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administration of oral midazolam 30 minutes before the procedure.

For distal and middle ductal sialoliths, the approximate location was identified using the landmarks obtained from the CBCT images and by palpation. An incision was made in the mucosa of the floor of the mouth overlying the calculus, and the duct was identified and incised over the sialolith, which was removed.

For proximal and hilar sialoliths, the mucosal incision was extended from the middle to the posterior floor of the mouth. The duct was identified in the

FIGURE 4. Patient 1. Cone-beam computed tomography image, 3-dimensional view of the medial aspect of the left mandible.

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FIGURE 5. Patient 2. Cone-beam computed tomography image, transverse sectional view, of a patient with multiple calculi located in the infundibulum of the right submandibular gland.

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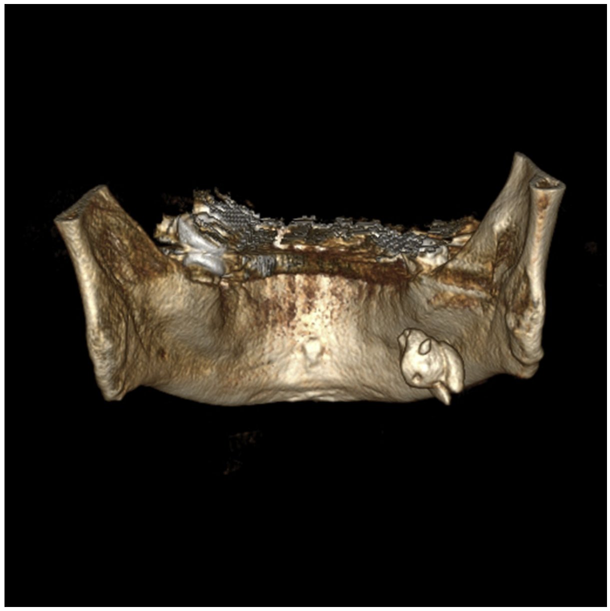

FIGURE 7. Patient 2. Cone-beam computed tomography image, 3-dimensional posterior view.

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anterior aspect of the incision, grasped, and then traced backward and dissected from the surrounding tissues. The lingual nerve was then visualized, carefully freed, and gently moved laterally by traction, protecting it during further dissection of Wharton's duct toward the hilum. The posterior margin of the mylohyoid announced the proximity of the hilum. The landmarks obtained from the CBCT evaluation were used as guides to identify the location of the calculi. The duct was incised over the calculi when they were palpable, or proximally, at the hilum, followed by posterior opening until the calculi were reached in the case of nonpalpable salivary stones. Knowledge of

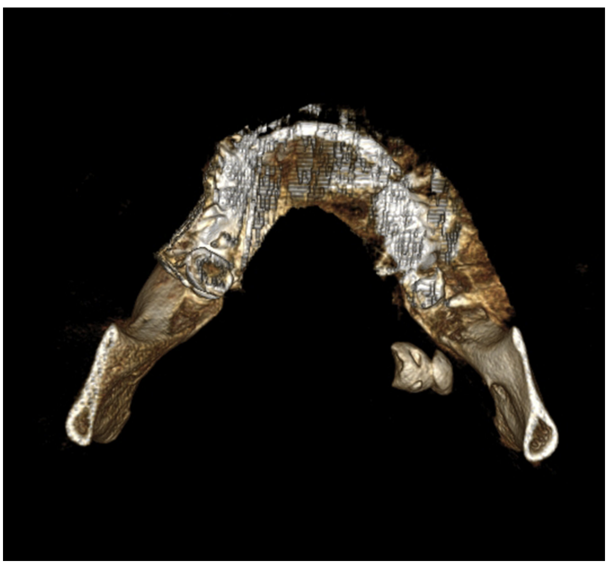

FIGURE 6. Patient 2. Cone-beam computed tomography image, 3-dimensional superior view.

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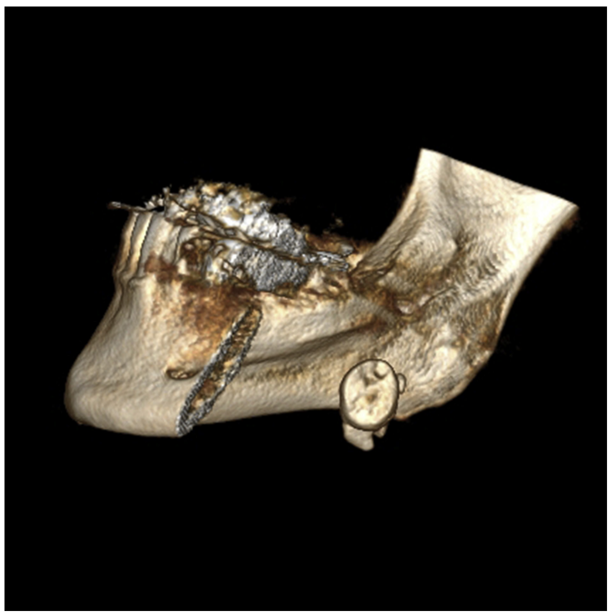

FIGURE 8. Patient 2. Cone-beam computed tomography image, 3-dimensional view of the medial aspect of the right mandible.

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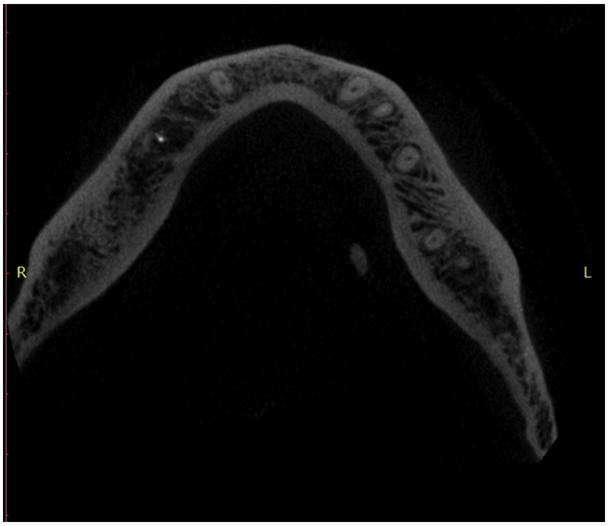

FIGURE 9. Patient 3. Cone-beam computed tomography image of a patient with a left submandibular sialolithiasis demonstrating 1 calculus in the glandular infundibulum and another in the middle third of Wharton's duct. Transverse sectional view of the ductal calculus showing its location in relationship to the roots of the first mandibular molar.

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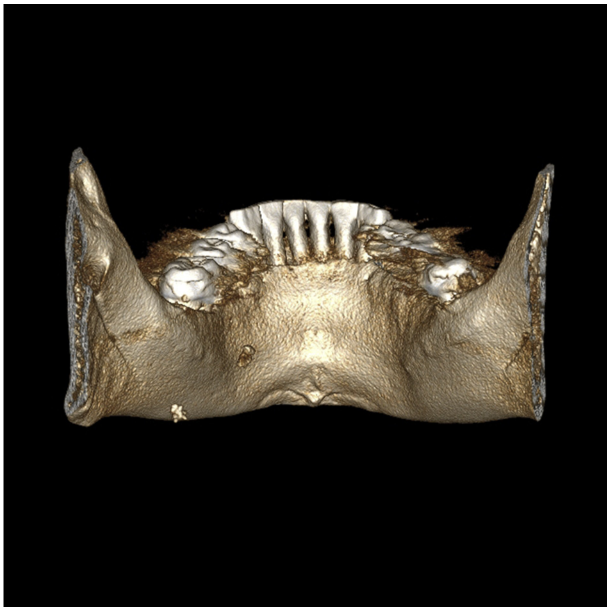

FIGURE 11. Patient 3. Cone-beam computed tomography image, 3-dimensional posterior view.

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the number, size, arrangement, and shape of the calculi was used to ensure complete removal.

At the end of the procedure, Wharton's duct was left open, without suturing the surgical opening to the oral mucosa nor direct closure of Wharton's duct. We also did not suture the mucosa of the floor of the mouth. An iodoform gauze was inserted into the surgical wound to keep the wound margins open, ensuring drainage and offering protection to allow for 1 week of secondary healing.

The patients were prescribed antibiotic and anti-inflammatory treatment for 7 days after surgery. Subsequent appointments for reevaluation occurred at 3, 6, and 12 months after sialolithotomy.

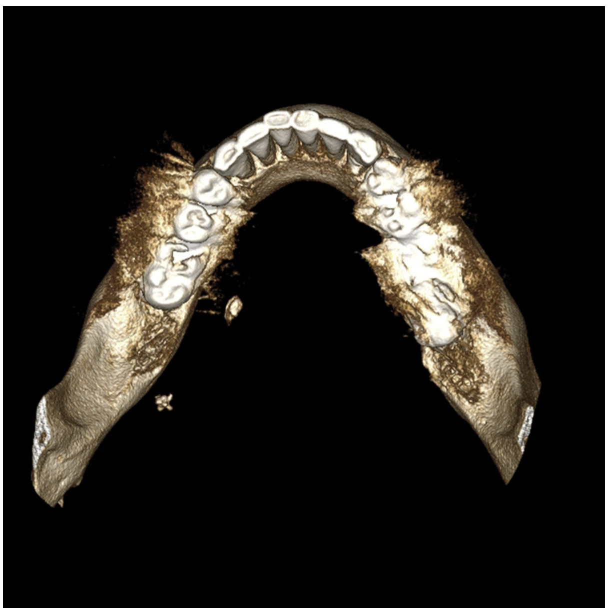

FIGURE 10. Patient 3. Cone-beam computed tomography image, 3-dimensional superior view.

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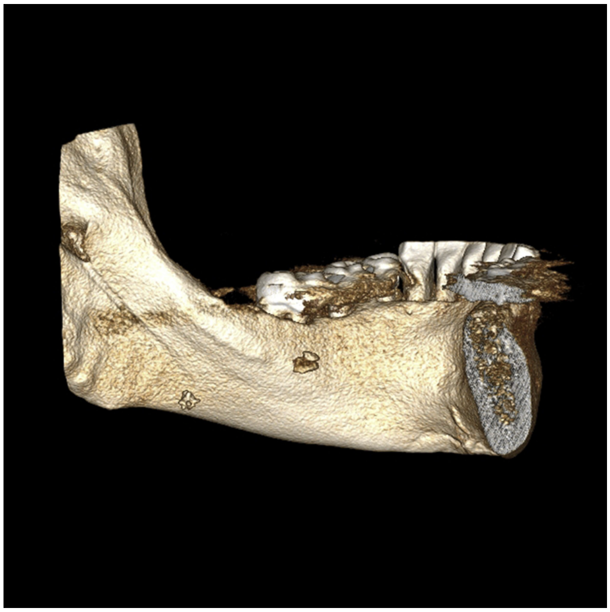

FIGURE 12. Patient 3. Cone-beam computed tomography image, 3-dimensional view of the medial aspect of the left mandible.

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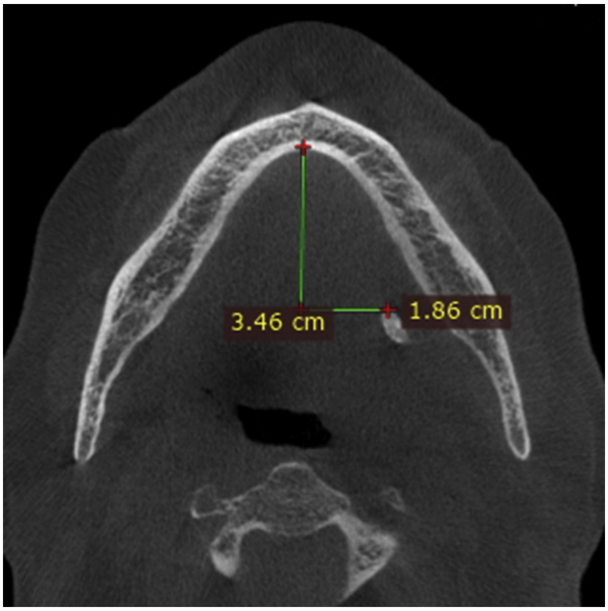

FIGURE 13. Patient 4. Cone-beam computed tomography image of a patient with left submandibular sialolithiasis showing the presence of a single calculus of relatively small dimensions located in the proximal ductal area. Transverse sectional view showing the measured distance landmarks for the approximate location of the calculus in relation to the midline, because dental landmarks were absent in the posterior mandible.

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Results

A total of 32 patients with submandibular sialolithiasis were included in the present study. The mean age of the selected patients was 42 years (range, 17 to 67 years). Of the 32 patients, 17 were male and 15 were female. The presenting episode was the first manifestation of the disease for 17 patients, and 15 patients had reported 1 to 3 previous episodes of obstructive symptoms in the previous 2 years that had received conservative treatment only.

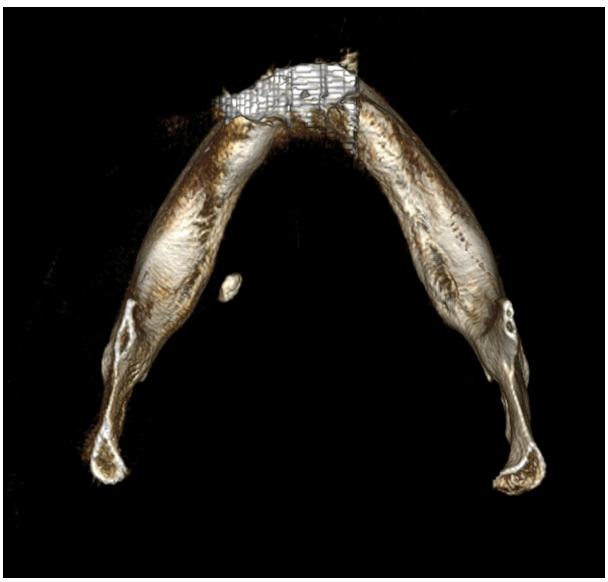

FIGURE 14. Patient 4. Cone-beam computed tomography image, 3-dimensional superior view.

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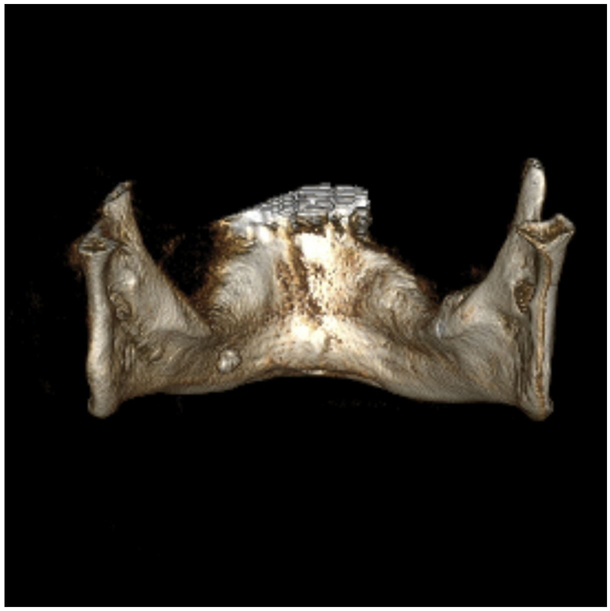

FIGURE 15. Patient 4. Cone-beam computed tomography image, 3-dimensional posterior view.

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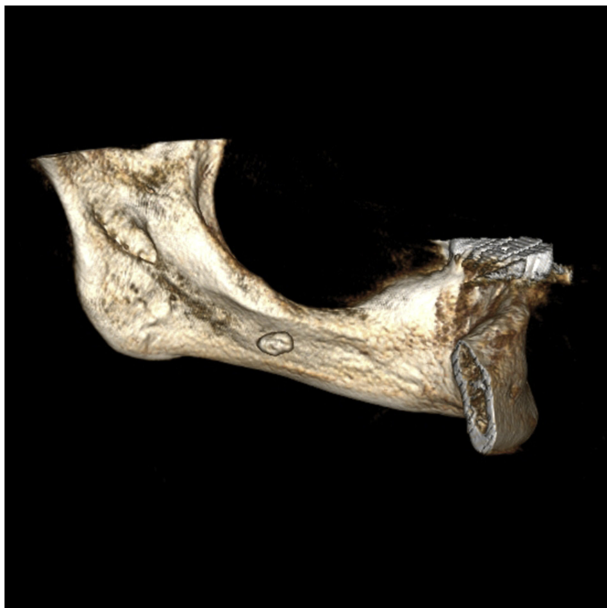

FIGURE 16. Patient 4. Cone-beam computed tomography image, 3-dimensional view of the medial aspect of the left mandible.

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Table 1. DISTRIBUTION OF SALIVARY CALCULI FOR INCLUDED PATIENTS

Variable	Distal	Middle Third	Proximal or Hilar	Multiple Locations	Multiple Sialoliths
Patients (n)	16 (50)	10 (31.25)	14 (43.75)	8 (25)	13 (40.62)
Sialoliths (n)	17	13	21	NA	NA
Nonpalpable (n)	3	3	4	NA	NA
Megaliths (n)	NA	NA	5	NA	NA
Smallest diameter (mm)	2	3	3	NA	NA
Largest diameter (mm)	7	6	41	NA	NA

Data in parentheses are percentages.

Abbreviation: NA, not applicable.

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Of the 32 patients, 16 (50%) had sialoliths located in the distal section of Wharton's duct, 10 (31.25%) had sialoliths in the middle section, and 14 (43.75%) had sialoliths in the proximal duct or hilar area. Eight patients (25%) had calculi present in more than 1 ductal region (Table 1). In addition, 19 patients (59.37%) had only 1 salivary calculus on presentation, and 13 patients (40.62%) had presented with multiple sialoliths. Ten patients (31.25%) had nonpalpable stones, with the sialoliths in the hilum in 4 patients (12.5%). No concurrent parotid gland lithiasis was found in the included patients.

The largest diameter of the calculi as measured on the CBCT scan was 7 mm in the distal section, 6 mm for middle portion calculi, and 41 mm for proximal and hilar calculi. A total of 51 sialoliths were diagnosed using CBCT. Five megaliths, defined as sialoliths greater than 1 cm in the largest diameter, were found, all in the proximal and hilar areas. The smallest diameter was 2 mm for a distal duct stone. The number of surgically extracted calculi was identical to the number found on CBCT evaluation. One megalith fragmented during removal; however, the fragments could be reconstituted to the previous shape shown on the 3-dimensional CBCT image; thus, complete extraction could be confirmed. The mean operating time was 30 minutes, including administration of locoregional anesthesia.

After surgery, 2 patients (6.25%) presented with lingual hypoesthesia that had resolved within the first 3 postoperative months. No infection or ranula formation and no recurrent obstructive episodes developed. No patient experienced persistent sialadenitis after surgery.

Discussion

Several investigators have already reported on the utility of CBCT in the accurate diagnosis of sialolithiasis.[7-9] We have highlighted the additional benefit of performing CBCT the day of sialolithotomy with the purpose of increasing intraoperative orientation by a better understanding of the location of the calculus relative to the surrounding anatomic structures considered as landmarks and minimizing the risk of calculus migration between the CBCT evaluation and the beginning of surgery.

Local anesthesia should be preferred owing to the smaller associated general risks, the possibility of performing the procedure in an office setting, and increased patient acceptability. Another advantage to the proposed technique is that the surgery and CBCT are both performed with the patient in a seated position, resulting in fewer variations in the position of the soft tissues, especially in the posterior floor of the mouth.

The palpability of the calculus has been considered by many surgeons one of the criteria for performing intraoral removal.[10-12] However, in the presence of a smaller calculus, or sialoliths located deeply and posteriorly in the hilar area, the palpation will not be a very accurate method of determining the presence and location of the sialolith. CBCT allows for an accurate diagnosis and also the definition of the spatial topography of the stone in relation to the surrounding structures. This will increase the surgeon's confidence in using an intraoral approach and increase the chances of finding the sialolith within a shorter period.

Useful anatomic landmarks have been described for the detection of the hilum area with patients under local anesthesia, under conditions of poor visualization of the surgical field, and difficult access in this posterior oral region. The surgical triangle described by Park et al[13] is formed by 3 main anatomic structures: the lingual nerve, the medial aspect of the mandible, and the posterior margin of the mylohyoid muscle. Although the surgical technique we used was not much different, the use of CBCT image analysis for preoperative case evaluation allowed for a preview of the patient's anatomy and the possibility of determining intraoperative landmarks. The use of CBCT also provides a method to verify complete removal by comparing the number and shape of the extracted calculi. These additional findings will be most important in the case of multiple calculi or megaliths, which are prone to fragmentation during removal. The shape of the sialolith viewed on a 3-dimensional CBCT image will help with reconstitution of the stone in the case of fragmentation, as was demonstrated in 1 of the patients in our series.

One subject of debate among surgeons has been the suturing of Wharton's duct and/or the mucosa of the floor of the mouth. Combes et al[14] sutured both the canal and the overlying mucosa separately. Zenk et al[12] created a new ostium by suturing the ductal mucosa to the oral mucosa. Woo et al[5] do not make a new opening for the duct but loosely sutured the mucosa of the floor of the mouth over it. In our case series, we performed no suturing of the duct or of the mucosa. The wound healed by secondary intention with the help of an inserted iodoform gauze. The results were favorable, with no cases of infection or recurrent obstruction, stenosis, or ranula formation. The operative time was also shortened, because the technically difficult suturing of Wharton's duct in the proximal aspect was avoided. In their study, Roh and Park[15] concluded that sialodochoplasty did not have any effect on preventing the recurrence of obstructive symptoms. The only significant contributing factor they found was the complete or incomplete removal of the salivary stones.[15] This was consistent with our results, because the absence of symptom recurrence in our case series can be explained by the verified complete removal of all previously detected calculi.

Sialolithotomy and submaxillectomy have both been associated with the risk of lingual nerve injury. However, during submandibular gland removal, several other nerves will also be in danger of damage, such as the marginal mandibular branch of the facial nerve and the hypoglossal nerve.[10,16] For this reason and supplemental cosmetic factors regarding the resulting scar and variable depression in the submandibular region, preservation of the submandibular gland should be preferred whenever possible. Studies have shown that submandibular gland function will resume after removal of the sialoliths.[5,6] Thus, sialolithotomy offers a more functional approach to managing submandibular gland calculi compared with submaxillectomy and should, therefore, be considered as a primary procedure for the management of sialolithiasis in the distal, proximal, or hilar areas.

In conclusion, our study has shown that gland preservation is feasible when treating submandibular lithiasis, with good results by performing sialolithotomy, with the patient under local anesthesia, as an office-based procedure, even in the presence of nonpalpable proximal and hilar calculi. The use of CBCT image analysis was significant for optimal determination of the location, number, and shape of the sialoliths and, in particular, for an optimal understanding of the 3-dimensional location of the salivary stones in relationship to the surrounding structures. The landmarks obtained from CBCT images increased the accuracy of calculi retrieval within a short operative time.

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