Perspectives from an Equine Expert Panel on Clodronate Use in Horses

DISCUSSION TOPICS

Clinical Experience

Case Selection

Short-Term Efficacy

Long-Term Efficacy

Safety

On May 14, 2019, a group of 12 leading experts in equine veterinary medicine participated in a panel to discuss their cross-disciplinary experiences and opinions on the use of clodronate in horses.

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Received: 8 June 2016 | Accepted: 22 February 2017
DOI: 10.1111/vsu.12680

ORIGINAL ARTICLE

Trans-endoscopic diode laser fenestration of equine conchae via contralateral nostril approach

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Abstract

Objective: To describe and report preliminary outcomes of a contralateral trans-nasal endoscopic laser fenestration of the conchae for endoscopic examination and treatment of paranasal sinuses in horses.

Study design: Cadaveric experimental and prospective clinical study.

Animals: Normal cadaveric equine heads (n = 7) and equine patients (horses n = 7, donkey n = 1) diagnosed with sinusitis.

Methods: Ex vivo: a video-endoscope containing a diode laser fiber in the working canal was passed through the nostril and retroflexed in the nasopharynx toward the contralateral conchae. Ventral or dorsal conchae were fenestrated. Duration of surgery, laser energy, visualization quality, and feasibility of sinoscopy through the fenestrations were recorded. In vivo: sinus drainage, sinoscopy 24 hours postoperatively, stoma persistence, and clinical results after 3 months were evaluated in 8 patients.

Results: Fenestrations were performed in 8 dorsal conchae (6 cadavers, 2 patients), 10 ventral conchae (5 cadavers, 5 patients), and 1 dorsal conchal bulla (1 patient). Visualization was good in 6 patients and affected by bleeding in 2 patients. Drainage through the fenestrations was observed in all patients. Trans-nasal sinoscopy was possible in all cadavers and in 6 out of 8 patients. Masses inside the sinuses precluded sinoscopy in 2 patients. Stomata persisted until discharge of the patients (mean of 14 days). Clinical signs improved in 6/8 patients.

Conclusion: The endoscopic approach reported here provides good visualization during the trans-endoscopic laser fenestration of the conchae. The fenestrations may allow a trans-nasal sinoscopic examination and treatment in selected cases of sinusitis in horses.

1 | INTRODUCTION

The complicated anatomy and relative inaccessibility of equine paranasal sinuses complicates the diagnosis and treatment selection of sinus disease. The current standard-of-care relies on direct observation and treatment of the equine paranasal sinuses via sinusotomy, performed under standing or general anesthesia.[1,2] Flap sinusotomy and trephination procedures may result in iatrogenic damage to underlying structures, and healing complications due to cellulitis, septic osteitis, or suture periostitis, which can also contribute to poor cosmetic outcomes.[2-5] Sinoscopy, performed through small transcutaneous trephination wounds, is an attractive alternative diagnostic tool, as this approach is less invasive and decreases the risk of complications.[3,4,6-9] The presence of a maxillary sinus septum separating the rostral and caudal compartments of the maxillary sinuses implies that a thorough endoscopic examination requires several trephinations or creation of an artificial communication through the maxillary sinus septum.[8] Sinoscopy performed through a small frontal trephination with fenestration of the maxillary septal bulla allows thorough examination of all paranasal sinus compartments.[9] This approach has been associated with a complication rate of 5%, consisting of sinocutaneous fistula, frontal exostosis, and cellulitis.[9] However, the limitations of a sinoscopy performed through small trephination wounds include insufficient postoperative drainage and the possibility of inadequate placement of trephine fistulas relative to individual anatomical variations, hindering examination and/or instrument manipulation.[5,8,9]

In man, surgical treatment of sinus diseases is commonly performed through a minimally invasive, trans-nasal endoscopically guided method, designated as functional endoscopic sinus surgery (FESS). The efficacy of FESS relies on the physical removal of debris, alteration, and opening of sinuses and drainage pathways to ensure continuous flow of mucus and sinus aeration.[10] FESS is designed to restore drainage from the maxillary, ethmoid, sphenoid, and frontal sinuses. In addition, maintaining the patency of the ostiomeatal complex plays a crucial role in re-establishing mucociliary clearance from the dependent sinuses. Achieving adequate drainage is instrumental in reversing the mucosal disease and subsequent symptoms in many cases.[11] In horses, a diode laser fiber attached to a vaporizing probe has been used in a minimally invasive trans-nasal technique to partially remove the dorsal concha under endoscopic control from the ipsilateral nasal passage and gain access to the conchofrontal and caudal maxillary sinus.[12] This approach allows diagnostic sinoscopy and drainage of the sinus but requires further evaluation in clinical cases.[13] Surgical fenestration between the sinuses and the nasal cavity leads to copious bleeding because the vascular nature of the nasal mucosa.[13] A vaporizing probe attached to a diode laser fiber was shown to successfully control the intraoperative hemorrhage.[12] However, this effect may not be extrapolated to the use of a bare diode laser fiber without further specialized equipment.

The first aim of this study was to evaluate a contralateral endoscopic approach to the conchae for trans-nasal fenestration of either ventral or dorsal concha utilizing a bare trans-endoscopic diode laser fiber. We were particularly interested in assessing intraoperative hemorrhage, the suitability of the fenestrations to serve as portals for trans-nasal sinoscopy and pathways for drainage, and the clinical outcome of patients treated with this technique. We hypothesized that a contralateral endoscopic approach to the conchae would provide good visualization during fenestration of the conchae, as any hemorrhage would be expected to follow gravity and flow in the rostral direction, thus away from the endoscope. We also hypothesized that the fenestrations could serve as portals for sinoscopy of the corresponding paranasal sinus compartments, and allow enough drainage to result in resolution of clinical signs in horses with sinus disease.

2 | MATERIAL AND METHODS

2.1 | Ex vivo study

Seven normal cadaver heads were harvested from horses euthanized for reasons unrelated to sinus disease. Age and breed of the horses were recorded. Specimens were selected to roughly represent a cross-section of age and breed categories of horses referred to our clinic due to sinus disease. Two heads were used only for dorsal concha fenestration, 1 head only for ventral concha fenestration and 4 heads were used for both procedures, so that 6 dorsal concha and 5 ventral concha fenestrations were performed. Heads were fixed in a head-stand used for dental procedures. A manual air pump was fitted to the larynx to mimic airflow during the procedure. The medical diode laser used in this study (Laser D-PLUS, Quanta System, Milan, Italy—maximum output 30 W, wavelength 980 nm) was equipped with a trans-endoscopic 600 μm laser fiber (Surgical Bare Fiber AS 400/440 IR ACF T, Quanta System). The laser was set to surgery mode (continual generation of radiation) at a power of 25 W.

A diode laser fiber was passed through the working canal of a flexible video-endoscope (140 cm long, 9 mm in diameter, Karl Storz, Tuttlingen, Germany). The endoscope was inserted in the nostril contralateral to the side of conchotomy, advanced into the nasopharynx and retroflexed around the caudal margin of the nasal septum. The tip of the endoscope was then directed dorso-rostrally to reach the ventral aspect of the dorsal concha (Figure 1) or ventro-rostrally to reach the medial aspect of the ventral concha. The caudal parts of the conchae corresponding to the location of conchal sinuses were fenestrated approximately at the level of a transition between the hard and soft palate, which is also the site of attachment of the nasal septum to the hard palate and thus the rostral margin of the choana (Figure 2). The laser fiber was advanced rostrally until the wall of the concha was reached. The laser was activated while slowly retrieving the fiber in contact with the tissue to create a 5 cm long full thickness linear incision (Figure 3). The incision was dilated with a metal urinary catheter for mares inserted through the ipsilateral nostril under endoscopic control from the approach described above (Figure 4). Duration of surgery and total energy delivered were recorded.

The degree of contamination of the endoscope with sanguineous fluid was recorded as nonlimiting when endoscopic visualization was maintained by rinsing the camera with the endoscope in situ. The degree of contamination was consisted as limiting when visualization required removal of the

FIGURE 1 Retro-flexion of the endoscope. The trans-endoscopic probe contacts the dorsal concha

endoscope for mechanical cleaning of the lens, or flushing of the operation site.

The endoscope was then inserted through the ipsilateral nostril to assess the suitability of the stomata to serve as portals for the trans-nasal sinoscopy of the corresponding compartment of the paranasal sinuses. The position of the endoscope inside the sinuses was checked radiologically in selected cases (Figure 5). The ability to complete trans-nasal sinoscopic examination of the corresponding paranasal sinus compartments was recorded in each case. Sinoscopic examination of the caudal system of paranasal sinuses was considered complete when a detailed view of the ethmoid, frontal sinus, infraorbital canal, and roots of the second and third molar was achieved. Complete examination of the rostral system included visualization of the ventral conchal sinus, infraorbital canal, and roots of the first molar within rostral maxillary sinus.

2.2 | In vivo study

Eight equine patients (7 horses and 1 donkey) diagnosed with sinus disease of either primary (n = 5) or secondary (n = 3) character were included with owner's permission. Fenestration of the ventral or dorsal concha was selected based on clinical and dental examinations, radiography, and endoscopy of the upper airway. These modalities were used to localize the disease to specific compartments of paranasal sinuses, and identify a preliminary or definitive cause. The trans-endoscopic laser fenestration relied on the same approach, equipment and laser setting described in the ex vivo study. This technique was used to fenestrate 5 ventral concha, 2 dorsal concha, and 1 fenestration of the bulla of the dorsal concha. The dorsal conchal bulla in case number 5 was enlarged, requiring a modification of the positioning the endoscope, compared to cases of dorsal conchal sinus fenestration: the tip of the endoscope was advanced as far rostrally as allowed by the conformation of choana and length of retroflexed portion (Figure 4).

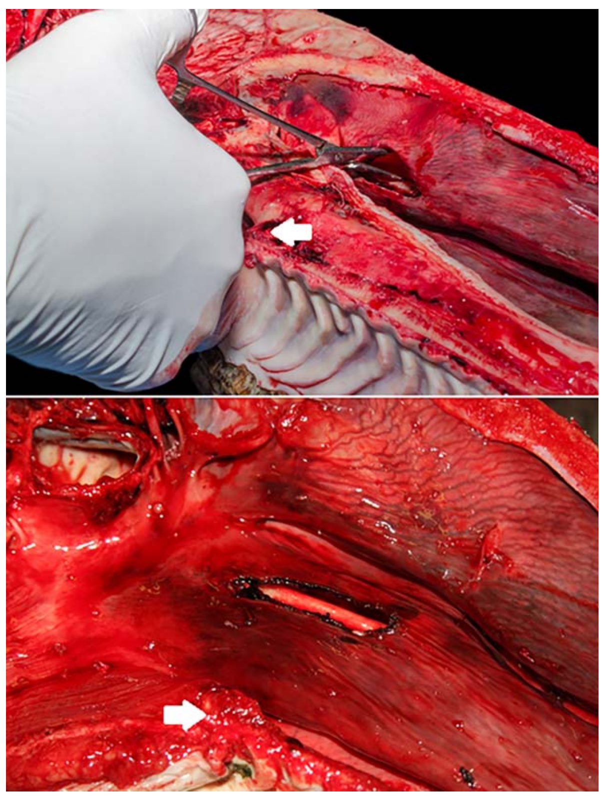

FIGURE 2 Dissected specimens in the ex vivo study. Note the anatomical placement of the fenestrations of the dorsal (top image) and ventral (bottom image) concha. Arrows indicate the transition between the hard and the soft palate

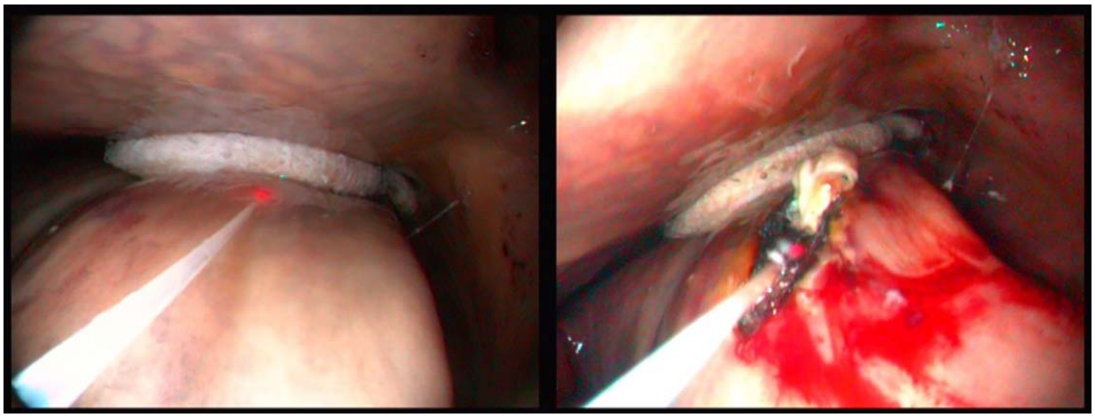

FIGURE 3 Fenestration of the ventral concha: blood and purulent material are draining away from the endoscope (case number 3)

All patients in the study were sedated with a standard protocol, including intravenous application of a bolus of detomidine (0.008 mg/kg; CP-Pharma Handelsges mbH, Burgdorf, Germany), butorphanol (0.020 mg/kg; Richter Pharma AG, Wels, Austria), and a constant infusion of detomidine (0.020 mg/kg/h), and butorphanol (0.013 mg/kg/h). A maxillary nerve block was performed via perineural application of 10 mL of 0.5% bupivacaine and Marcaine 0.5% bupivacaine hydrochloridum (Astra Zeneca UK Limited, London, United Kingdom) on the operated side, and 25 mL of 2% lidocaine (Lidocain 2%—lidocaini hydrochloridum, EGIS PHARMACEUTICALS, Budapest, Hungary). Patients with dental sinusitis (cases 2, 3, and 6) underwent a standing tooth extraction on the same day, just before the trans-endoscopic laser conchotomy.

To reduce bleeding, the heads of horses were fixed at the height of the withers; tampons soaked with adrenalin (Epinephrini hydrochloridum 0.1%, Zentiva, Prague, Czech Republic) and ephedrine (ephedrine 1% nasal drops, Sv. Anna Hospital Pharmacy, Brno, Czech Republic) were applied topically to achieve local vasoconstriction in the wall of the concha. A total of 25 mL of ephedrine nasal drops and 5 mL of adrenalin were used per procedure. The operation site was flushed with cold water through the ipsilateral nasal passage with a plastic tube and a manual pump, when copious bleeding interfered with endoscopic visualization. The nasal passage was packed with gauze when the incision was completed. Packing was removed the next day.

Horses received per-oral antibiotherapy consisting of doxycycline 10 mg/kg, metronidazole 20 mg/kg twice daily for at least 10 days after surgery, and intravenous anti-inflammatory medication (flunixin-meglumin 1, 1 mg/kg once daily for at least 4 days).

Trans-nasal sinoscopy of the involved paranasal sinus compartments was attempted 24 hours postoperatively. This lag phase was chosen to allow hemostasis and minimize bleeding during trans-nasal sinoscopy. Trans-endoscopic sinus lavage was performed daily in cases where sinoscopy was possible until discharge from the hospital. In cases 3 and 8, the diseased sinuses were flushed not only trans-endoscopically (or using a trans-nasal catheter under endoscopic control) but

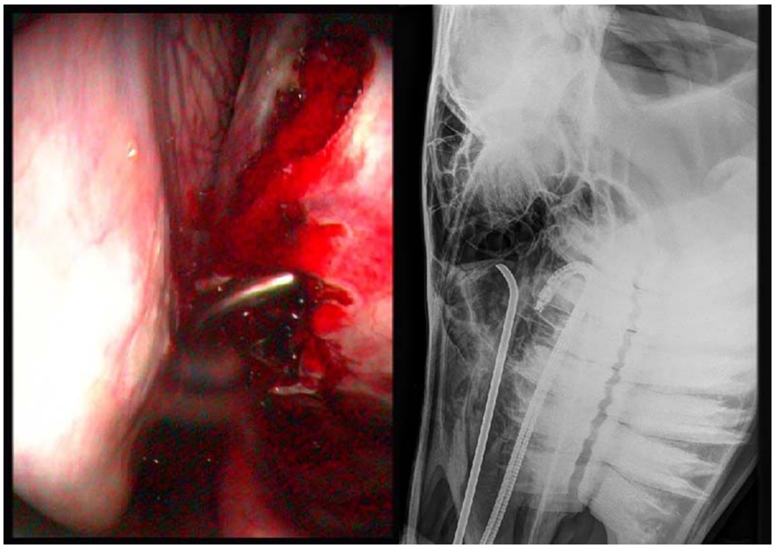

FIGURE 4 Use of a metal catheter to dilate an incision in the bulla of the dorsal concha under endoscopic control (case number 5)

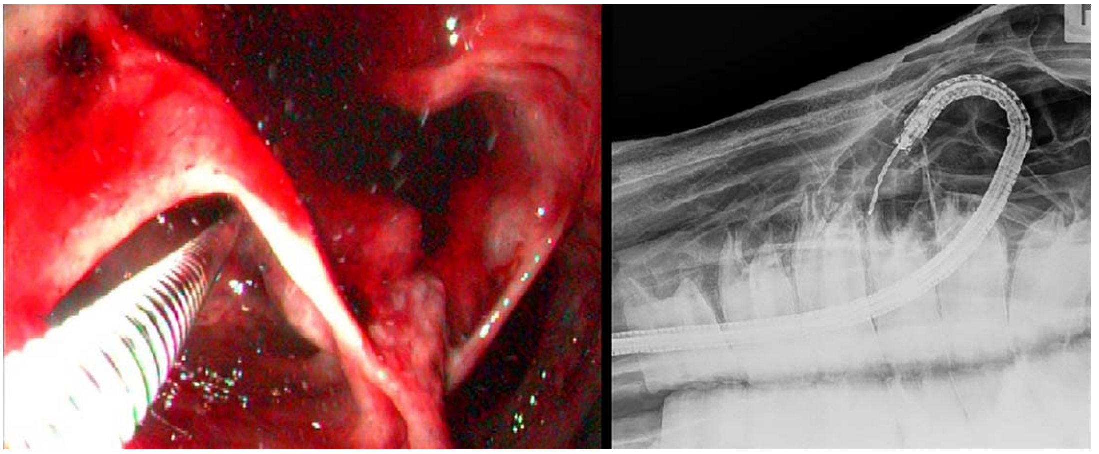

FIGURE 5 Ex vivo endoscopy of the rostral compartment of the maxillary sinus (roots of the first molar)

also through a rostral maxillary sinus opening created by drilling with a 4-mm diameter Steinmann pin into the sinus through a stab incision. A nonsterile (tap water and NaCl) isotonic solution was used for lavage of the sinuses.

The same parameters were recorded during in vivo and ex vivo procedures. In addition, drainage from the sinus through the fenestration, persistence of the stoma and clinical outcome were recorded. Patency of the stoma was confirmed by passing the endoscope or metal catheter through the fenestration. The last endoscopic recheck was performed on the day of hospital discharge, except case 5, which was re-evaluated 46 days postoperatively. Clinical outcome (positive/negative) was assessed after 3 months based on a phone questionnaire. A positive clinical outcome was defined as a resolution of the unilateral nasal discharge without recurrence 3 months after discharge. The outcome was considered as negative if the nasal discharge was not resolved or recurred within 3 months.

3 | RESULTS

3.1 | Ex vivo study

Six dorsal concha and 5 ventral concha were fenestrated in 7 horses (Table 1). The mean energy of the laser beam energy

TABLE 1 Summary of age and breed of equine cadavers, site of fenestration, energy and time required for laser fenestration of the conchae for each procedure, degree of endoscope contamination, and extent of subsequent sinoscopy

Cadaver number	Age (years)	Breed	Conchotomy	Laser beam energy (J)	Time (min)	Sinoscopy	Limiting endoscope contamination
1	11	Noriker	Dorsal concha	7850	17	Complete CS[a]	No
2	20	Czech warmblood	Dorsal concha	8155	22	Complete CS	No
3	12	Polish warmblood	Dorsal concha	8432	24	Complete CS	No
3	12	Polish warmblood	Ventral concha	8652	19	Complete RS[b]	No
4	7	Noriker	Dorsal concha	9120	20	Complete CS	No
4	7	Noriker	Ventral concha	8530	22	Complete RS	No
5	25	Czech warmblood	Dorsal concha	8412	16	Complete CS	No
5	25	Czech warmblood	Ventral concha	8850	20	Complete RS	No
6	20	Thoroughbred	Dorsal concha	8370	16	Complete CS	No
6	20	Thoroughbred	Ventral concha	8200	14	Complete RS	No
7	24	Old Kladrubian horse	Ventral concha	8450	15	Ventral conchal sinus	No
Mean	17			8456	19		

Abbreviations: CS, caudal system; RS, rostral system.
[a]Caudal system of paranasal sinuses (conchofrontal, caudal maxillary sinus).
[b]Rostral system of paranasal sinuses (ventral conchal and rostral maxillary sinus)

was 8456 kJ (7850-9120 kJ, standard deviation 343 kJ) and the procedure lasted a mean of 19 minutes (14-24 minutes, standard deviation 3 minutes, Table 1).

The volume of sanguineous fluid retained post-mortem in the submucosal venous plexuses and draining spontaneously from the laser incisions was limited compared to the bleeding observed later in the living patients. Nevertheless, the stream of this fluid followed gravity and the direction of exhaled air, thereby flowing away from the endoscope. Retro-flexing the endoscope and approaching the conchae from the nasopharynx made it possible to optimize the position of the endoscope to prevent its contamination and to allow adequate visualization during all 11 procedures. Trans-nasal sinoscopic exploration of the corresponding compartments of paranasal sinuses was possible after all 11 procedures. Sinoscopy was limited to the ventral conchal sinus in cadaver 7 due to an anatomical variation consisting of a thin septum between the ventral conchal and rostral maxillary sinus, subsequently confirmed by dissection. Complete trans-nasal sinoscopy of the corresponding paranasal sinus compartments was possible in the remaining 6 cadavers.

3.2 | In vivo study

Fenestrations were performed in 5 ventral conchae, 2 dorsal conchae, and 1 dorsal conchal bulla in 8 horses with sinus disease (Table 2).

A diagnosis of primary sinusitis was established if no specific underlying pathology was detected during the diagnostic evaluation and empyema was the only abnormality on trans-nasal sinoscopy. Primary sinusitis was diagnosed in cases 1, 4, 5, 7, and 8. A diagnosis of dental sinusitis was established if dental infection was identified on dental and radiological examinations, such as in cases 3 and 6. Dental pathology was initially identified in case 2, but an invasive space-occupying mass was detected while attempting trans-nasal sinoscopy, eventually histologically classified as adenocarcinoma.

The mean laser energy was 8449 kJ (7850-9125 kJ, standard deviation 439 kJ). The procedure lasted 26 minute (mean, 17-35 minutes, standard deviation 7 minutes) and bleeding was classified as nonlimiting in terms of quality of endoscopic view in 6/8 cases.

Trans-nasal sinoscopy of the corresponding compartments of paranasal sinuses was possible in 6/8 cases. The conchofrontal and caudal maxillary sinus were completely visualized in the 2 cases with fenestration of the dorsal concha. Sinoscopy was limited to visualization of the ventral conchal sinus and infraorbital canal without further access into the rostral maxillary sinus in all 3 cases where the ventral concha was fenestrated. The interior of the dorsal conchal bulla was visualized after its fenestration in one case.

Complete trans-nasal sinoscopy of the caudal compartment of the paranasal sinuses was possible after fenestration of the dorsal concha in cases 1 (Figure 6) and 7. Case 7 had marked mucosal swelling in the concho-frontal sinus the day after conchotomy, and sinoscopy could only be completed once swelling has resolved, after 6 days of antibiotic and anti-inflammatory treatment. In cases 3, 4, and 8, sinoscopy was possible although limited to the ventral conchal sinus due to mucosal swelling and hypertrophy. Endoscopic visualization of the complete interior of the dorsal conchal bulla was possible after its debridement in case 5.

Drainage of liquid from the sinus through the fenestration was noted in all 8 cases. Subsequent trans-nasal sinus lavage was possible in all cases, either trans-endoscopically, or through a metal catheter placed under endoscopic control from the nasal passage.

In cases 2 and 6, the fenestration was disturbed by copious bleeding and sinoscopy was precluded by space-occupying soft tissue masses, subsequently diagnosed histologically as adenocarcinoma in case 2 and an inflammatory polyp in case 6. Both cases required subsequent sinusotomy in order to collect tissue samples and resulted in negative clinical outcomes.

In horses with primary sinusitis (cases 1, 4, 7, 8), the drainage of purulent content followed by repeated trans-nasal lavage combined with antibiotic and anti-inflammatory treatment led to resolution of signs and a positive clinical outcome.

In case 3, the trans-endoscopic sino-nasal fistulation and lavage greatly facilitated the removal of a large volume of inspissated pus accumulated in the sinus of the ventral concha secondary to dental sinusitis. Trans-nasal debridement of inspissated pus and necrotic tissue from the dorsal conchal bulla was also successfully achieved in case 5. Clinical outcome was positive in these 2 cases.

Owners reported a positive clinical outcome in 6/8 cases, at 3 months postoperatively, while a negative outcome was noted in 2 cases, nasal discharge did not resolve or worsened.

The persistence of the stomata was confirmed in all cases via endoscopy and was consistent with the duration of hospitalization (mean of 10 days, 7-14 days) as the last endoscopic recheck was performed on the day of discharge. Patency of the stoma was confirmed via endoscopy in one case (Case 5) 46 days postoperatively. If this value is taken into consideration, the mean time of confirmed stoma persistence increases to 14 days. Persistence of the stoma was not evaluated after discharge in any of the remaining cases.

4 | DISCUSSION

The results of this study support the suitability of trans-endoscopic laser fenestration to establish sinoscopic portals

TABLE 2 Summary of age, breed and diagnosis of equine patients, site of fenestration, energy and time required for laser fenestration of the conchae for each procedure and degree of endoscope contamination

Case	Age (yr.)	Breed	Diagnosis	Conchotomy	Laser beam energy (J)	Time (min)	Limiting endoscope contamination	Sinus drainage	Sinoscopy	Known stoma persistence (days post op.)	Clinical outcome
1	9	Czech warmblood	Primary sinusitis, CS[a]	Dorsal concha	8325	17	No	Yes	Complete CS	7	Positive
2	12	Noriker	209 pulpitis, RS[b] sinusitis adenocarcinoma	Ventral concha	7850	32	Yes	Yes	Impossible	7	Negative
3	9	Slovakian warmblood	209 pulpitis, dental sinusitis RS	Ventral concha	8470	20	No	Yes	Ventral conchal sinus	11	Positive
4	8	Thoroughbred	Primary RS sinusitis	Ventral concha	8420	35	No	Yes	Ventral conchal sinus	14	Positive
5	6	Thoroughbred	Dorsal conchal bulla empyema	Dorsal conchal bulla	8230	20	No	Yes	Dorsal conchal bulla	46	Positive
6	15	Andalusian donkey	209 pulpitis, RS mass (hypertrophic sinusitis)	Ventral concha	9125	30	Yes	Yes	Impossible	12	Negative
7	9	Polish warmblood	Primary sinusitis CS	Dorsal concha	8120	25	No	Yes	Complete CS	8	Positive
8	10	Thoroughbred	Primary RS sinusitis	Ventral concha	9050	30	No	Yes	Ventral conchal sinus	8	Positive
Mean	10				8449	26				14	

Presence of drainage from the fenestration, extent of subsequent sinoscopy, confirmed stoma persistence, and clinical outcome are stated.

Abbreviations: CS, caudal system; RS, rostral system.

[a]Caudal system of paranasal sinuses (conchofrontal, caudal maxillary sinus).

[b]Rostral system of paranasal sinuses (ventral conchal and rostral maxillary sinus).

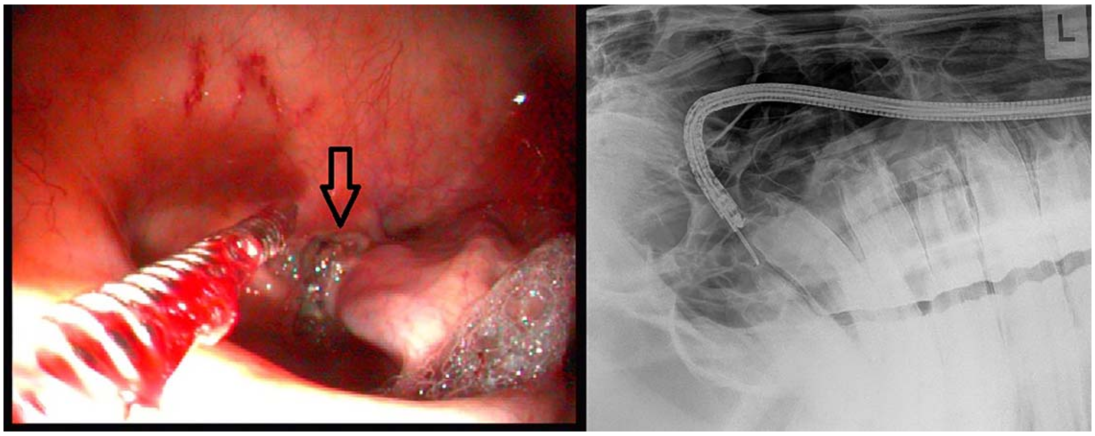

FIGURE 6 Endoscopy of the caudal compartment of paranasal sinuses: inspissated pus (arrow) is present behind the roots of the third molar (case number 1)

and establish drainage in selected cases of sinus disease. This study also reveals limitations associated with the fenestration technique and use of fenestrations as sinoscopic portals.

Moderate to severe bleeding occurred in all clinical cases, limiting visualization in 2/8 cases. Although the procedure remained feasible in all cases, the procedure would be improved by limiting associated bleeding. The submucosa of the nasal passage contains a rich and complex network of anastomosing vessels supplied primarily by the sphenopalatine artery.[14] Fenestration sites were selected based on dissection of cadaveric specimens, to identify areas of the conchae with the thinnest wall. These sites are likely to have the least vascularity, which makes them suitable locations for sino-nasal fistulation. Complete avoidance of vessels via a specific anatomical placement of the incision does not seem practical. Instead, improving hemostasis appears a more viable strategy to limit intraoperative bleeding with during the procedure.

The diode laser used in this study was selected for its efficiency, ease of use, and availability in many referral clinics. Use of neodymium:yttrium aluminum garnet (Nd: YAG) laser may improve hemostasis. Higher energy levels (40-100 W) can be used for noncontact coagulation and ablation of tissue in the upper respiratory tract of horses with the Nd: YAG laser and gas-cooled fiberoptic delivery systems. Noncontact ablation of tissue with high energy levels allows deep penetration of energy into the tissues (up to 0.5 mm) to coagulate blood vessels and causes delayed thermal necrosis.[15] Thermal damage within the conchal wall may increase the size of the stomata and prolong their persistence. Although the newer diode lasers can generate up to 50 W of energy, the bare fiberoptic delivery systems used with these lasers do not effectively transmit the high energy levels to tissues while in the noncontact mode.[15] Based on our observation during this study, the fiber is almost parallel to the surface of the concha (regardless of the endoscopic approach used) when the tip of the endoscope is inserted into the nasal passage, complicating application in non-contact mode. Attempts to coagulate the mucosa with a laser beam at lower energy output in a contact mode prior to the incision failed to reduce bleeding during the procedures performed in this study. Direct incision of the concha with a laser set to a high power output accelerated the procedure, allowing early packing of the nasal passage and thus reducing blood loss. Contact application, which seems inevitable in this particular case, can be enhanced by use of a contact tip fiber. Contact tip fibers include sculpted quartz fibers, contact-tipped sapphire fibers, metal-capped fibers, temperature-controlled bare fibers, and dual effect (used both in contact and noncontact modes) fibers.[16] Further studies are indicated to test the suitability of such fiber designs for fenestration of conchae. A vaporizing probe efficiently evaporated the wall of the concha with minimal bleeding.[12] Such fiber tips and probes were not available for our study. Instead, our goal was to test a bare diode laser fiber commonly used for other upper airway surgeries. Based on our observations, we believe that the bare diode laser fiber provided insufficient hemostasis for the procedure reported here. The use of specialized equipment for intraoperative hemostasis may require modifications of the technique. Indeed, some contact tips are too large for insertion through flexible endoscopes.[16] Maneuvering the endoscope through the contralateral nasal cavity and retroflexing it in the nasopharynx with a contact probe already attached to the laser fiber may be difficult. Such tips or probes can be used with the laser fiber passed through a separate application device as reported by Morello and Parente.[12] The endoscopic approach via contralateral nasal passage described in this study would be compatible with insertion of a separate application device through the ipsilateral nasal passage, potentially facilitating manipulation of the instrument. Alternatively, an electrocautery could be inserted through the ipsilateral nostril and manipulated in the nasal passage under endoscopic control, as described for the blunt metal catheter used for dilation of the fenestration in this study. Use of instrumentation improving coagulation would facilitate the fenestration, but could also eliminate the need for postoperative packing of the nasal cavity, thereby allowing immediate use of the fenestrations as sinoscopic portals.

Trans-endoscopic laser fenestration of the sinus cavities has not been performed routinely in practice partly because of the time required for adequate tissue vaporization. Laser evaporation of the conchal wall has been found significantly slower than the time needed to trephine the sinus for conventional sinoscopy.[12] Prolonged surgical time is perceived as a clear disadvantage of the laser fenestration of the conchae.[12] The average duration of the procedure in our study was shorter than previously reported by Morello and Parente,[12] but the trans-nasal sinoscopy was delayed by at least 1 day due to bleeding or swelling of the mucosa of the diseased sinus.

The position and size of the linear fenestrations of the conchae allowed complete trans-nasal sinoscopy of the corresponding compartments of paranasal sinuses in the ex vivo study. Complete sinoscopy of the rostral maxillary sinus via the sinus of the ventral concha was not achieved in the in vivo study. Use of a smaller diameter endoscope may facilitate trans-nasal examination of the rostral compartment of the paranasal sinuses. Chronic inflammation in horses with sinus disease may result in distort the architecture of affected sinuses and induce local thickening of the mucosa, thereby complicating or preventing trans-nasal fenestration of the conchae and sinoscopy.[17-19] Large masses located within the sinuses not only interfere with the trans-endoscopic fenestration of the conchae but also prevent the trans-nasal sinoscopy. Soft tissue opacity inside the sinuses, noted during thee preoperative radiological examination, was initially not classified as a solid mass in of the cases reported here. A space occupying mass was first identified while attempting trans-nasal sinoscopy and later confirmed by sinusotomy in 2 cases. In such cases, maxillary or fronto-nasal bone flaps appear diagnostically and therapeutically preferable over sinoscopy.

Although fenestrations of the medial wall of the ventral concha did not allow complete sinoscopy of the rostral compartment of the maxillary sinus in clinical patients, the entry into the ventral conchal sinus was easy and allowed examination, drainage, and debridement of this cavity. Examination of the ventral conchal sinus is very important in dental-related sinus disease because it is a frequent site of accumulation of inspissated exudate, which is difficult to remove and treat successfully.[1,20] Fenestration of the medio-ventral wall of the dorsal concha seemed relatively easier than fenestration of the ventral concha, in terms of maneuvering of the endoscope and visualization. Position of the incision in the dorsal concha facilitates the passage of the endoscope from the middle nasal passage into the conchofrontal and caudal maxillary sinus. Fenestration of the dorsal conchal bulla was technically simple, with the endoscope positioned similarly as during dorsal concha fenestration. Trans-nasal laser fenestration of the conchal bulla has been described as an effective part of the treatment of its empyema.[21] The effectiveness of the treatment of the inflamed sinus depends on adequate drainage either through a patent nasomaxillary opening or through surgically created openings into the nasal cavity.[22] Drainage of exudate from the sinuses through the fenestrations was observed in all clinical cases in this study. Although the need for sino-nasal fistulation to drain sinuses is questioned in the literature,[13] removal of purulent material accumulated in the sinuses through the fenestrations appeared to play an important role in the treatment of cases included in this study. Sino-nasal fistulation has been proposed to alter mucociliary clearance and lead to chronic sinus problems.[23] Such complications were not observed in our study, but limited sample size and short-term follow-up prevent us from excluding this risk.

Several retrospective studies of horses with sinusitis have reported high rates of recurrence and repeated surgeries.[3,6,24,25] Prolonged patency of defects within the conchae may not only facilitate drainage of the chronically diseased sinus but also serve as portals for long-term endoscopic reassessment.[12] The results of this study do not provide sufficient evidence regarding the persistence and patency of the fenestrations. At the time of discharge, stomata were narrowed by edema of the mucosa and growth of granulation tissue, but measured approximately the same length as the original laser incisions, accommodating a 9-mm diameter endoscope or a metal catheter. The stomata are therefore likely to remain patent for a longer period of time, as evidenced by case 5. Further studies should evaluate the persistence of these stomata as functional entities for sinoscopy and sinus drainage.

Our results support our hypothesis in terms of the suitability of a contralateral endoscopic approach for laser fenestration of the ventral and dorsal conchae in horses. Our study confirms that these fenestrations can be used as portals for trans-nasal sinoscopy and assist in the therapy of paranasal sinus disease. These encouraging results warrant further clinical investigations into the application of the technique and long-term results in patients. This technique may eventually provide diagnostic and therapeutic options in horses with sinus disease, following the general trend toward the minimally invasive management of upper airway diseases.

5 | CONCLUSION

Our study describes a contralateral endoscopic approach for laser fenestration of the ventral and dorsal conchae in horses with a diode laser fiber. Approaching the caudal parts of the conchae from the nasopharynx by retro-flexion of the endoscope helps reduce complications related to bleeding. Sinonasal fistulation achieved in this study allows trans-nasal sinoscopy, trans-endoscopic lavage, and drainage of the sinuses. This approach seems to contribute to the diagnosis and treatment of horses with selected paranasal sinus diseases. This study provides a proof-of-concept for a minimally invasive alternative to sinusotomy. Further research is needed to optimize the method, especially with regards to intraoperative hemostasis. Studies including a larger population of patients are needed to further evaluate its efficacy in all forms of sinus disease in horses.

CONFLICT OF INTEREST

The authors declare no conflict of interest related to this report.

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How to cite this article: Kološ F, Bodeček Š, Žert Z. Trans-endoscopic diode laser fenestration of equine conchae via contralateral nostril approach. *Veterinary Surgery*. 2017;46:915-924. https://doi.org/10.1111/vsu.12680