How to Perform Minimally Invasive Sinoscopy

Alvaro G. Bonilla, DVM, MSc, DACVS

Author’s address: University of Montreal, Department of Clinical Sciences, Faculty of Veterinary Medicine, 3200 Rue Sicotte, Saint-Hyacinthe, QC J2S 2M2, Canada; e-mail: aa.garcia.bonilla@umontreal.ca. © 2021 AAEP.

1. Introduction

The diagnosis and treatment of sinus pathologies remain a challenge mainly due to their complex anatomy and the diagnostic limitations of traditional imaging techniques.1,2 Once drainage is identified at the nasomaxillary opening during upper airway endoscopy (50–100% of the cases), radiography and dental examination are commonly the next diagnostic steps used by equine practitioners to diagnose sinus pathology.1,2 Unfortunately, a definitive diagnosis is only reached in 40% of affected cases with radiography, and dental examinations are often unrewarding to identify apical pathology.1–3 Thus, required techniques to improve this diagnostic rate tend to be either expensive and/or unavailable (computed tomography [CT]) or invasive (traditional sinoscopy is performed through a 10-15-mm trephination) for most practitioners. The main objective of the study was to develop and describe a minimally invasive sinoscopic technique (MIST) that simplifies the surgical approach/invasiveness of the traditional technique to perform sinoscopy while allowing a thorough sinus evaluation.4 In addition, a secondary objective was that MIST should be relatively simple to perform and learn and that it can be performed either in a hospital or ambulatory setting for practitioners with a good knowledge of sinus anatomy. Last, three different sinoscopic approaches were evaluated and compared to determine what approaches would be recommended to perform. The author’s institution hypothesized that MIST would be simple to perform and that at least 2 approaches would be required to obtain a thorough evaluation of the sinuses.

2. Materials and Methods

To perform the MIST, a flexible and disposable 2-mm-diameter and 18-cm-long endoscopea was designed in collaboration with a veterinary endoscopy company (Fig. 1). This endoscope is longer and flexible when compared to the traditional needle endoscopea commonly used to perform standing arthroscopy in horses but is compatible with the same arthroscopic console. The endoscope lacks a control knob, a flush system, or an instrument channel; however, its price is significantly lower than a specialized 2-mm endoscope with the aforementioned features. In order to identify the ideal landmarks to perform MIST and to determine the thoroughness of sinus evaluation, cadaveric heads from horses older than 5 years old and of various common breeds were used. Then, the technique was carried out in healthy horses to determine the suitability of the technique in live horses and validate it. Last, MIST was performed in selected clinical patients either after primary recommendation by the attending clinician or when CT examination was not a diagnostic option for the owner.

Sinoscopic Landmarks

The traditional landmarks to perform sinoscopy/trephination were slightly modified (Fig. 2) to be able...
to obtain a thorough sinus evaluation with the 2-mm endoscope.4–6

1. To access the frontal sinus, the mini-sinusotomy was performed at 40% of the distance from the medial canthus of the eye to midline and 2 cm caudal to the rostral aspect of the rostral lacrimal tubercle, with the needle inserted perpendicular to the bone. The rostral lacrimal tubercle is a bony prominence palpable just rostral and slightly dorsomedial to the medial canthus and serves as the insertion point for the orbicular muscle.

2. To access the caudal maxillary sinus, the mini-sinusotomy was performed 1 cm rostral and 3 cm ventral to the rostral aspect of the rostral lacrimal tubercle, with the needle inserted perpendicular to the bone.

3. To access the rostral maxillary sinus, the mini-sinusotomy should be performed 40% of the distance from the rostral end of the facial crest to the level of the medial canthus and 1 cm ventral to a line joining the infraorbital foramen and the medial canthus, with the needle directed slightly upwards (approximately 30°). This needle orientation facilitates advancement of the scope over the infraorbital canal.

MIST
The following structures were evaluated during the MIST (Fig. 3):

- From the frontal sinus approach (FS): ethmoid, caudal recess of the frontal sinus (FS “cul-de-sac”), caudo-medial aspect of the dorsal conchal sinus, fronto-maxillary opening, maxillary septal bulla (MSB), caudal aspect of the caudal maxillary sinus, infraorbital canal, entrance to the sphenopalatine sinus, and roots of maxillary teeth 110/210 and 111/211.

- From the caudal maxillary sinus approach (CMS): ethmoid, fronto-maxillary opening, MSB, infraorbital canal, entrance to the...
sphenopalatine sinus, caudal aspect of the caudal maxillary sinus, and roots of maxillary teeth 110/210 and 111/211.

- From the rostral maxillary sinus approach (RMS): roots of maxillary teeth 108/208, 109/209, and 110/210, infraorbital canal, MSB, and ventral conchal sinus (VCS).

A grading score was assigned for each evaluated structure: 3 for complete visualization, 2 for subcomplete (approximately 51-99% of the structure visualized), 1 for partial or limited (approximately 1-50% of the structure visualized), and 0 for no visualization. Only during this cadaveric phase, and after enlarging the frontal mini-sinusotomy with a 5-mm Steinmann pin, the MSB was fenestrated under endoscopic guidance with a 14-G catheter trocar. The fenestration was made at the level of the infraorbital canal (medial to lateral direction) and as dorsal and rostral as possible in the segment of the MSB protruding through the fronto-maxillary opening. The flexible endoscope was then inserted through the newly created opening, and the RMS and VCS were evaluated.

MIST in Healthy Horses

1. Horses were premedicated with procaine penicillin (22 000 UI/kg IM) and phenylbutazone (2.2 mg/kg IV), sedated with detomidine (0.01 mg/kg IV) and butorphanol (0.01 mg/kg IV), and restrained in standing stocks.
2. The region overlying the paranasal sinuses was clipped and aseptically prepared. Skin and subcutis were anesthetized with 1 mL of lidocaine hydrochloride 2% at the selected landmarks (Fig. 1).
3. A 3-mm stab incision was performed with a number-11 scalpel blade through the skin and soft tissues until contacting bone. Next, a mini-sinusotomy/trephination was created by advancing a 3.8-cm-long, 14-G needle (2.1-mm diameter) through the frontal (FS approach), zygomatic, or lacrimal (CMS approach) and maxillary bones (RMS approach) with the aid of a mallet.
4. The needle was then removed with circular movements to allow enlargement of the mini-sinusotomy and thereby facilitate entry of the 2-mm flexible endoscope.
5. Sinoscopy evaluation through the FS, CMS, and RMS approaches was then carried out in each horse (Fig. 4).
6. After sinoscopy, the sinuses were flushed with approximately 500 mL of isotonic solution to prevent secondary infection, and an adhesive bandage was placed around the head for 2 days. The skin incisions were not closed.
7. The endoscope was only wiped with alcohol before each procedure.

Procedural time started at the time of the first incision and ended after sinuses were lavaged. Any intraoperative or postoperative complications were recorded. A Wilcoxon-signed rank test (Prism, GraphPad Software, San Diego, CA) was performed to determine the best approach to examine the CMS (FS versus CMS). A p value of less than 0.05 was considered statistically significant. For clinical patients, the procedure was carried out as aforementioned, although preprocedural antimicrobials and postprocedural sinus lavage were not used. In addition, the endoscope was cleaned and sterilized with cold sterilization before each procedure due to the higher risk of bacterial contamination during the procedure in clinical cases with sinusitis.

3. Results

Cadaveric Specimens

Breeds included during the cadaveric phase (10 horses) were 4 Standardbreds, 3 Quarter Horses, 1 Percheron, 1 Hanoverian, and 1 Welsh pony. A variety of breeds were included to be able to validate the technique in horses of most sizes. In cadaveric specimens (mean age of 12 years old and range of 6-20 years old), most evaluated structures (9/11 for FS and 8/8 CMS) received a median score of 3 (range 2-3) through the FS and CMS, which indicated a thorough sinus evaluation during these approaches. A median score of 2 (range 0-3) was obtained for the craniomedial aspect of the dorsal conchal sinus and the caudal cul-de-sac of the frontal sinus. As it occurs with traditional sinoscopy, manipulation of the endoscope within the RMS was limited, and scores obtained were lower (median and range of 3 and 0-3, respectively). Five out of the six structures evaluated had a median score of at least 2.5 (range 2.5-3); however, the median score for the visualization of the caudal tooth roots of 08s was 0 (range 0-3). Fenestration of the MSB to improve visualization of the VCS and RMS was attempted during the cadaveric phase. Unfortunately, the RMS and/or VCS was completely visible in only 3
specimens, and MSB perforation was abandoned in subsequent phases of the study.6

Healthy Horses

Results obtained from 6 medium-size healthy horses (mean age of 15 years old and range of 13-18 years old) were similar to the cadaveric phase for the FS and CMS approaches. Additionally, both study phases revealed that there was no difference for the visualization of the structures within the CMS when the FS and CMS approaches were compared (p = 0.32). Thus, the CMS approach was considered as optional for clinical cases. With regard to the RMS approach, a score of 3/3 was obtained for all structures, which significantly improved the results obtained in the cadaveric phase for the tooth roots of 08s. Thus, the technique was considered to be validated for its use on live horses. The procedure took 34.2 ± 5.8 minutes (all 3 approaches) to be performed, and all horses tolerated the procedure well. Two to three gentle taps of the mallet were generally enough to go through the bone with the 14-G needle to perform the 2.1-mm mini-sinusotomy. Foggling or darkening of the field of view was frequently encountered upon endoscope introduction on live horses. Nonetheless, this quickly resolved by either contacting an adjacent mucosal surface or by cleaning the endoscope tip with a wet gauze before reintroducing the endoscope within the sinuses. No personnel or equipment damage occurred. No intraoperative complications were noted during the procedures other than mild petechiation in the RMS mucosa in 3/6 horses. This was associated to contact of the endoscope with the sinus mucosa while cleaning the endoscopic lens. All horses developed mild (2-cm diameter or less) subcutaneous emphysema at the level of the mini-sinusotomies within a few hours of the procedure that lasted between 12 and 24 hours. In one horse, moderate emphysema (4-cm diameter around the RMS mini-sinusotomy) extended rostrally and ventrally after MIST and persisted for 72 hours. All incisions were macroscopically healed upon bandage removal 48 hours after the procedure, and the cosmetic appearance was considered excellent for all horses but one. This horse developed local thickening (1.5 cm × 1.5 cm) at the FS mini-sinusotomy, which resolved after 2 weeks. No signs of sinus or incisional infection were noted postoperatively.

Clinical Cases

To date, the MIST has been used in 8 clinical cases since its introduction to the clinic (Fig. 5 and Table 1). The technique has been considered useful for case management (confirmed lack of sinus involvement [2/8], obtained a definitive diagnosis [2/8], or guided surgical approach [3/8]) in 7/8 cases. In one case, severe and diffuse pus presence in all sinus compartments prevented appropriate sinus visualization with the MIST despite sinus lavage was attempted. However, the technique partially helped to decide the surgical approach (maxillary sinus flap in this case. Regarding the MIST approaches performed in clinical cases, 5 horses received the FS and RMS approaches, while 3 horses received the FS approach only. No intra- or post-MIST complications were encountered other than mild self-limiting subcutaneous emphysema in at least 2 cases. Unfortunately, the self-limiting nature of the emphysema and the retrospective nature of the study prevented obtaining more information in this regard. In one horse presenting fluid accumulation in the rostral sinuses based on radiography, the FS mini-sinusotomy was enlarged with a 7-mm Steinman pin to allow guided perforation of the MSB while visualizing the area with the 2-mm endoscope. This approach allowed inspissated pus removal and lavage of the rostral sinus compartments with a sinusotomy half the size of a traditional trephination. Telephone follow-up information revealed neither recurrence from the original sinusal problem nor presence of complications associated to MIST or treatment in 7/8 cases (5/8 horses are alive and 2/8 were euthanized due to a severe colic episode months after MIST). Euthanasia during hospitalization due to poor progression was carried out in the case with the comminuted mandibular fracture.

4. Discussion

The MIST allowed thorough paranasal sinus evaluation in horses thanks to a novel 2-mm flexible endoscope introduced through a mini-sinusotomy performed with a 14-G needle (2.1 mm) in standing sedated horses. The mini-sinusotomy itself is easy to perform and does not require special expertise or instrumentation. In fact, this technique is routinely used in the author’s institution for sinus sampling or lavages. In contrast, appropriate knowledge of sinus anatomy is necessary to perform and interpret the sinoscopic images obtained with MIST. Sinus anatomy is complex, but recent open-access literature (Anatomy and Diagnostic Imaging of the Equine Paranasal Sinuses, Educational Resources, University of Georgia) and performance of anatomic dissections can greatly facilitate practitioners’ self-learning. Small-diameter flexible endoscopes with a

Fig. 5. Representative sinoscopic images from clinical cases showing a case with inspissated pus around the tooth roots of 211 (left), a sinus cyst protruding into the caudal maxillary sinus (center), and an "ethmoid" hematoma in the caudal maxillary sinus (right).
<table>
<thead>
<tr>
<th>Age (years) Breed</th>
<th>Presenting Complaint</th>
<th>Diagnostics Performed</th>
<th>MIST Approach and Findings</th>
<th>Usefulness of MIST</th>
<th>Final Diagnosis</th>
<th>Treatment</th>
<th>Follow-up (time)</th>
</tr>
</thead>
</table>
| 1. 18 Quarter Horse | Right CMND | R, DE, NE | - FS and RMS
- Diffuse pus in CMS
and unidentified structured covered by pus | Yes, guided surgical approach | Sinus bony sequestrum in the CMS | Maxillary sinus flap: sequestrum removal and sinus lavage | No complications or recurrence (32 months) |
| 2. 8 Thoroughbred | Left CMND | R, DE, NE | - FS and RMS
- Pus in CMS | Yes, guided surgical approach | Chronic CMS sinusitis | Maxillary sinus flap: pus removal and sinus lavage | No complications or recurrence EUR (8 months) |
| 3. 8 Warmblood | Right CMND | R, DE, NE | - FS and RMS
- CMS hematoma and pus in RMS | Yes, final diagnosis | CMS hematoma, RMS sinusitis and nasal mycosis | FS and RMS trephination: hema-toma and pus removal, sinus lavage and nasal lavage/ debridement | No complications or recurrence (34 months) |
| 4. 11 Pony | Left nasal masses | R, DE, NE, CT | - FS and RMS
- No abnormalities (performed before CT) | Yes, ruled out sinus patholgy | Nasal osteomyelitis | Mass removal through rhinotomy | No complications or recurrence (13 months) |
| 5. 4 Appendix | Right CMND | R, DE, NE | - FS
- Maxillary sinus cyst | Yes, final diagnosis | Maxillary sinus cyst | FS trephination: cyst removal | No complications or recurrence (30 months) |
| 6. 16 Quarter Horse | Left CMND | R, DE, NE | - FS
- Pus within FS and CMS | No, pus obscured visualization | CMS hematoma and secondary sinusitis | Maxillary sinus flap: hematoma and pus removal and sinus lavage | No complications or recurrence EUR (30 months) |
| 7. 18 Canadian | Severe left periorbital swelling | R, DE, NE | - FS
- No abnormalities | Yes, ruled out sinus patholgy | Comminuted mandibular fracture | Conservative treatment | Euthanasia during hospitalization |
| 8. 3 Quarter Horse | Left CMND | R, DE, NE | - FS and RMS
- Pus in RMS | Yes, guided surgical approach | Chronic RMS sinusitis | FS trephination: pus removal and sinus lavage | No complications or recurrence (9 months) |

Abbreviations: CMND, chronic malodorous nasal discharge; R, radiography; DE, dental examination; NE, nasal endoscopy; CT, computed tomography; FS, frontal sinus; RMS, rostral maxillary sinus; CMS, caudal maxillary sinus; EUR, euthanized for unrelated reasons.
control knob, flush port, and instrument channel are currently available on the market. However, they are cost-prohibitive and prone to damage.7,8 Thus, The author’s institution used a 2-mm endoscope that is affordable (approximately $600) and reusable. To date, the same endoscope has been used for all clinical cases without being damaged, although it was anticipated that they have a limited life span, and can be damaged if used forcefully. With regard to sterilization, sinoscopy is not a clean procedure due to the bacterial population normally present in the sinuses, and as such, endoscope sterilization may not be required. However, it is likely recommended to sterilize the endoscope with cold sterilization between procedures as most clinical cases where the endoscope will be used will present active infection. The reported landmarks should be respected to allow adequate manipulation of the endoscope within the sinuses and thereby exhaustive sinus evaluation. These modified landmarks were the result of information gathered during the cadaveric phase of the study and highlight that precision is required when performing a smaller sinusotomy (2.1 vs. 10 mm) for sinoscopy. The flexible endoscope was easy to manipulate and allowed a rapid evaluation (approximately 30 minutes) of the paranasal sinus without significant complications. To facilitate introduction and manipulation of the endoscope within the sinuses, it is crucial to perform circular movements with the 14-G needle once the mini-sinusotomy has been performed, with the goal of enlarging it. It is recommended to use two hands to manipulate the endoscope. A hand close to the mini-sinusotomy portal is used to introduce or withdraw the endoscope, while the other hand is used by the camera piece to allow 360° rotation of the endoscope, which is needed to thoroughly explore the sinuses. It is also recommended to perform all the mini-sinusotomies first and then carry out the MIST through each portal. This approach will promote clotting at the sinusotomy sites and therefore minimize sinus bleeding, which may obscure the field of view during sinoscopy. Bleeding was not a problem in healthy horses or clinical patients even though the latter presented mucosal inflammation secondary to the pre-existing sinus pathology. As previously mentioned, there were no visualization differences between the CMS and the FS approach to explore the CMS in healthy horses. Thus, the CMS approach was not performed in clinical cases and should be reserved for cases where the FS approach does not allow thorough evaluation of the CMS (i.e., when there is a very prominent bulla of the MSB that reduces visualization of teeth 10 and 11). In fact, the FS approach allows a look into the CMS with perspective, which is beneficial in horses where the sinus is partly filled with pus. In contrast, the minimal invasiveness of this technique and the lack of a control knob in the 2-mm flexible endoscope does not allow routine perforation of the MSB to look with perspective into the RMS and the CVS. This is a limitation of the technique that was bypassed in healthy horses with the RMS approach. It was believed that the bone of live horses was softer than in cadavers and that this allowed further enlargement of the mini-sinusotomy and therefore better visualization of the roots of teeth 08. However, the experience with clinical cases has revealed that visualization of the small rostral sinus compartments in cases where there is significant pus accumulation could be challenging. In those cases, performing a sinus lavage through a 14-G needle to reduce the sinus contents before attempting MIST could be recommended, although it may be unsuccessful in cases with inspissated pus. Thus, selected cases may benefit from enlarging the FS sinusotomy and perforating the bulla at that stage as it was carried out for horse 8. Last, only performing the FS approach may be deemed required. This was the case in 3 clinical cases where the FS approach was enough to obtain a definitive diagnosis (1), to guide treatment (1), or to rule out caudal sinus pathology (1). No major complications were found during MIST, hospitalization, or follow-up. Complications such as wound infection, bone sequestrum, or suture exostosis, which are commonly associated with trephination for traditional sinoscopy, were not found and are unlikely to occur considering the reduced invasiveness of this technique.9 Postprocedural emphysema was absent or minimal in clinical cases when compared to healthy horses. This is thought to be associated to the mucosal inflammation present in the sinuses of affected cases, which may have sealed the mini-sinusotomy hole after the procedure and prevented air from leaking into the subcutis. Regardless, emphysema is transient and resolves within days if present. Gentle needle insertion (gentle mallet taps during insertion) while performing the mini-sinusotomy of the RMS is strongly advised. This will prevent iatrogenic damage to the infraorbital canal as it is located close to the maxillary bone at this level. The MIST was conceived as a diagnostic alternative to CT and traditional sinoscopy that could allow popularization of sinoscopy among practitioners due to its simplicity and reduce invasiveness and morbidity. The author believes that with minimal training, practitioners may become proficient in the technique. Nevertheless, CT should still be considered as the gold standard to diagnose sinus pathology, and traditional sinoscopy can be used for diagnostic and therapeutic purposes, while MIST is mainly conceived for diagnostic purposes. The reported technique should be especially useful for practitioners without access to CT, those working in an ambulatory setting, and/or those looking for a simpler sinoscopic technique. Furthermore, the technique has shown value as a screening technique. It ruled out sinus involvement in two cases where sinus affection by infection was still considered possible after initial work-up and basic imaging (radiography and nasal endoscopy). In the institution where the study was performed (secondary referral hospital), the number of cases receiving MIST
is increasing; however, it is worth mentioning that many horses presented for sinus disease still go directly for CT due to its superior diagnostic rate, the availability at the institution, and the chronicity and complexity of most of the cases admitted. This should not necessarily be the case for most equine practitioners or primary hospitals. The technique presents several limitations. First, the technique requires a practice investment to purchase the endoscopic console, although practices performing standing arthroscopy may already have it. Second, the flexible endoscope lacks a control knob and a flush system, although this can be bypassed by manually guiding the endoscope within the sinus and by directly cleaning the lens with a wet gauze or by contacting sinus mucosa when fogging is identified. Fogging was not a problem in clinical cases. Third, it requires some degree of training and a good knowledge of sinus anatomy. However, the learning curve is not steep. Last, more clinical cases are needed to determine the diagnostic capabilities of the technique for each of the different sinus pathologies. To summarize, MIST is a diagnostic alternative to CT and traditional sinoscopy that can be used in addition to traditional imaging. MIST offers the advantage of being portable, involves a less invasive approach, and is performed rapidly and with a lower cost to clients, although specialized equipment is required. Additionally, MIST could rule out sinus involvement or assist treatment by providing information regarding the ideal location for treatment portals (trephine or flap).

Acknowledgments

BioVision donated equipment for the development of the technique. The study was funded by the Equine Health Funds supported by Zoetis and the Centennial Funds of the College of Veterinary Medicine of the University of Montreal.

Declaration of Ethics

The Author has adhered to the Principles of Veterinary Medical Ethics of the AVMA.

Conflict of Interest

The Author has no conflicts of interest.

References and Footnotes


"Virkon™, Vetoquinol N.A. INC, Princeville, QC G6L 4X1, Canada