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Efficient primary surgical treatment of equine infectious sinusitis reduces postoperative aftercare and increases outcome results: a retrospective study of 130 cases

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OBJECTIVE
To document the long-term outcome of surgically treated primary and dental-related sinusitis in horses and to describe a simple protocol for postoperative management.

METHODS
All surgically treated sinusitis cases referred between January 2016 and June 2022 were reviewed. Cases diagnosed with primary and dental-related sinusitis and with a follow-up of at least 6 months after hospital discharge were included. Cases with other sinus pathology were excluded.

RESULTS
130 cases met the inclusion criteria. 104 out of 130 were treated with sinoscopy and 26/130 with sinusotomy. 86 out of 130 cases (66.2%) were diagnosed with a dental pathology as a cause of sinusitis that required tooth extraction. Diagnostics were refined with the help of CT in 55/130 (42%) cases. Short-term complications were encountered in 8/130 (6.2%), and full response after initial treatment was successful for 107/130 cases (82.3%). The mean number of postoperative daily flushes was 3.15, and horses were discharged after a mean hospitalization period of 6.4 days.

CLINICAL RELEVANCE
Thorough debridement of sinuses affected by primary or dental-related sinusitis followed by a simple aftercare protocol can lead to a positive long-term outcome.

Keywords: sinusitis, dentistry, treatment, postoperative, infectious

Equine sinonasal disorders have been described in horses since the late 19th century.[1] Sinusitis in horses can sometimes be a challenge to treat in the case of chronic clinical signs. Recent studies[2,3] have shown the benefits of CT as a diagnostic tool to assess sinus disorders in horses and the use of sinoscopy in both the diagnosis and treatment of these pathologies.

Sinusitis in equine patients can be described as primary (dysbacteriosis of the sinus flora) or secondary when a concurrent disease, such as dental pathology, head trauma, neoplasia, space-occupying mass, etc, is the primary cause of the pathology.[4,5]

Chronic equine sinusitis has been historically treated by osteotomy flaps under general anesthesia with high risks of morbidity, mortality, and hemorrhage and high costs. These procedures are now more commonly performed on standing horses under sedation.[6] More recently, sinusitis has been investigated and treated using sinoscopic[7,8] or transnasal approaches.[9,10]

Sinoscopic treatment is especially considered the gold standard for the treatment of sinusitis in horses,[2] although some cases still require more invasive approaches. The postoperative aftercare protocols vary between referral centers and are dependent on the extent of the encountered pathology. It can be time consuming and might lead to less desired cosmetic scarring depending on the surgical technique used and the postoperative healing.

The objectives of this study are to document long-term follow-up of surgical treatment for equine primary and secondary dental-related sinusitis using sinoscopy or sinusotomy and to assess the impact of a simplified postoperative treatment on outcome results.

Methods

Case records

The study design was a retrospective, descriptive, large cohort case series. Medical records for horses that underwent surgical treatment of a paranasal sinus disorder at the Department of Large Animal Surgery and Anesthesiology of the Faculty of Veterinary Medicine of the University of Gent between January 2016 and June 2022 were reviewed.

Case information included anamnesis, patient sex, breed, age, duration of clinical signs before presentation, clinical signs during the examination, previous treatment attempts, and concurrent disease if such a pathology was treated (eg, pituitary pars intermedia dysfunction). One hundred sixty-five cases treated for paranasal sinus disorders were identified in the database. For the purpose of the present study, only cases that involved dental-related sinus disease or primary sinusitis were withheld. All other sinus pathologies, such as sinonasal cysts, progressive ethmoid hematoma, neoplastic disease, mucocele, etc, were excluded.

The cases that met the inclusion criteria were then divided into 2 groups according to the invasiveness of the surgical procedure. Group 1 included the horses that were treated using a minimally invasive sinoscopic technique, and group 2 included the horses treated by more invasive approaches, such as maxillary bone flap, frontonasal bone flap, or caudally based bilateral frontal bone flap.

Long-term follow-up was obtained by either routine reexamination at the clinic or by a telephone questionnaire to the owner. Treatment was considered successful if the horse showed no reappearance of nasal discharge or clinical signs for a minimum of 6 months after surgery.

Clinical examination

To identify any dental pathology that could be the cause of secondary sinusitis, all patients underwent a complete physical examination, an upper respiratory airway endoscopy of both nasal air passages (Dr Fritz 8-mm flexible endoscope), and a complete oral examination using oral endoscopy (Karl Storz Dental Endoscope; Medicam HD Camera).

Diagnostic imaging

Standard radiographic projections (left and right dorsal to ventral 30° oblique projections, a latero-lateral projection, and a dorsoventral projection) were performed on every patient and assessed by a European College of Veterinary Diagnostic Imaging diplomate.

If radiographic images were not conclusive, a CT examination of the horse's head was performed using a 320-row scanner (Aquilion One; Canon Medical Systems). The following parameters were used for the CT image acquisition: slice thickness, 0.5 mm; rotation time, 0.5 s; field of view, 50 cm; exposure settings, 250 mA and 135 kV; and 512 X 512 matrix **(Figure 1)**.

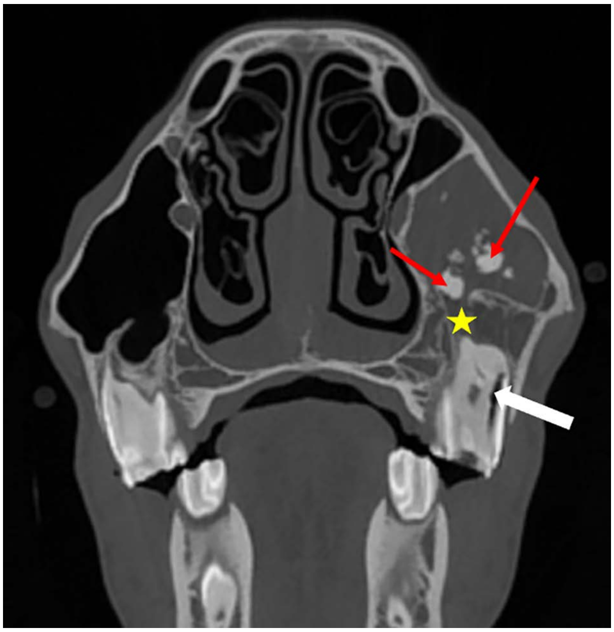

Figure 1—CT image showing features of an apical infection with decreased density indicative of gas (white arrow), an interruption of the lamina dura (yellow star), and dystrophic mineralizations (red arrows).

Surgical decision-making

A sinoscopic approach was the first-choice treatment in all cases. Sinusotomy was preferred when considered necessary based on the extent of the encountered pathology such as, eg, dystrophic mineralization too wide to be removed through a sinoscopic portal.

Sinoscopy technique (group 1)

After surgical preparation and local anesthesia with lidocaine, a 6-cm vertical incision including skin, subcutaneous tissues, and periosteum was performed with a No. 24 scalpel blade centered on landmarks as proposed by Ruggles et al.[7] The periosteum was elevated, and the frontal bone was trephined with a 16-mm-diameter Galt trephine. The caudally visible sinus compartments were inspected by endoscopy after flushing out (sterile 0.9% NaCl) and/or aspirating liquid or solid pus. The septal bulla was resected with Ferris Smith rongeurs to access the rostral sinus compartments following local anesthesia with 5 mL of lidocaine. Any purulent material or necrotic cartilage was further removed using flushing and aspiration under endoscopic guidance.

After the final inspection of the sinuses and before closing the surgical incision in 2 layers, the tissues were rinsed with sterile 0.9% NaCl, and the surgeon changed gloves. Periosteum and subcutaneous tissues were closed using a simple continuous pattern with resorbable sutures (Vicryl USP 2-0). The skin was sutured in the same manner. Finally, the surgical wound was protected with an adhesive bandage (Animal Polster) covering sterile compresses for 24 hours.

Postoperative care included administration of NSAIDs (eg, flunixin meglumine at 1.1 mg/kg, q 12 h, for 5 days; phenylbutazone at 2.2 mg/kg, q 12 h, for 5 days; and meloxicam at 0.6 mg/kg, q 24, h, for 5 days) and antimicrobial drugs. Patients received penicillin Procaine (22,000 UI/kg, q 24 h) for 3 days followed or not by trimethoprim and sulfadiazine (15 mg/kg/5 mg/kg per os, q 12 h) or doxycycline (10 mg/kg per os, q 12 h). Sinuses were flushed once a day with 1 liter of sterile 0.9% saline solution using a 16-gauge needle passed through the soft tissues overlying the sinoscopic bone defect **(Figure 2)**. Flushings were stopped when clear liquid drained from the nose.

Figure 2—Location of the 16-gauge needle used to postoperatively flush the right sinuses of a horse that underwent sinoscopic treatment of chronic sinusitis.

Sinusotomy (group 2)

The decision to perform sinusotomy under standing neuroleptanalgesia or general anesthesia was based on the extensiveness of the encountered pathology and the character of the horse. Some procedures were started standing and had to be finished under general anesthesia due to the impossibility of fully desensitizing the horse's sinuses. Horses that underwent sinusotomy in standing conditions received the same preoperative protocol as described for sinoscopy.

Maxillary and frontonasal sinusotomy—As for sinoscopy procedures, the head was clipped and surgically prepared. A maxillary nerve block using 5 mg of bupivacaine hydrochloride (Aspen) on the affected side was performed according to the technique described by Staszyk et al.[11] After local infiltration anesthesia of the skin and soft tissues, a "U"-shaped osteotomy was made following the surgical landmarks described by Lane[12] for the maxillary bone flap and by Freeman et al[13] for concho-frontal flaps.

Foreign materials such as dystrophic mineralizations were removed from the sinus compartments followed by copious flushing with 0.9% sterile saline. If excessive bleeding was encountered from manipulated conchal structures, hemostasis was achieved by packing the sinuses with gauze bandages that were passed through the ventral conchal wall with the help of a narrow nasogastric tube, toward the nose.

The bony flap was then repositioned in its physiological position, soft tissues were thoroughly flushed, and the surgeon changed gloves before apposition of periosteum and subcutaneous tissues with a simple interrupted suture at both corners of the bone flap followed by 3 simple continuous suture patterns, 1 at each side of the "U"-shaped incision (Vicryl 2-0 USP; Ethicon). The skin was closed using titanium surgical staples (Appose ULC; Covidien). For maxillary sinusotomies, 2 trephination holes were created using a 3-mm-diameter Steinmann pin, 1 on each side of the maxillary sinus septums, to allow postoperative sinus flush. A single trephination hole was created for fronto-nasal osteotomies, centered on the frontal sinoscopy landmarks.[7]

The postoperative aftercare protocol was the same as described for sinoscopy. Hemostatic sinus packages were removed 48 to 72 hours postoperatively. Sinus flushing was done with a 16-gauge needle passed through the trephination holes.

SENMAP-modified 4 X 4-cm sinusotomy—When obstruction of the nasomaxillary aperture (NMA) was preoperatively diagnosed as the primary cause of recurrent sinusitis, a modified surgical enlargement of the NMA was performed on standing horses. To access the medial edge of the ventral conchal sinus, a 4 X 4-cm square flap centered on the landmarks proposed by Bach et al[14] was created. Dissection to achieve enlargement of the NMA was done using electrocautery and Ligasure equipment. The preoperative protocol and postoperative aftercare were the same as described previously.

Results

One hundred thirty cases met the inclusion criteria. One hundred four were treated with a sinoscopic approach, and 26 were treated using sinusotomy. The breed, gender, age distribution, and affected side are reported **(Table 1)**. The duration of clinical signs and general diagnostics of the cause of sinusitis are described **(Table 2)**.

Table 1—Distribution of 130 equine cases affected with primary or secondary (dental pathology) sinusitis in terms of breed, gender, age, and affected side.

Parameter	Number and years
Breed (n)	
Warmblood	94
Pony	11
Draft horse	9
Thoroughbred	5
Purebred	5
Donkey	6
Affected side (n)	
Left	69
Right	56
Bilateral	5
Gender (n)	
Mare	65
Gelding	61
Stallion	4
Age (y)	
Minimum	0.83
Maximum	32
Mean	13.6

Table 2—Duration of clinical signs and general diagnostics.

Duration and diagnostics	Days and cases
Mean duration of clinical signs (range)	114 days (1–1,227)
Sinusitis	
Primary	44/130 (33.8%)
Secondary to dental pathology	86/130 (66.2%)

Group 1 (sinoscopy): 104 cases

Anamnesis and diagnostics—Among the 104 cases on which a sinoscopy was performed, 8 patients had a history of previous oral extraction before developing unilateral discharge. The mean duration of clinical signs in this group of patients was 110 days, ranging from 1 to 1,227 days. Fifty-seven out of 104 (54.8%) of patients exhibited right nasal discharge, 44/104 (42.3%) left nasal discharge, and 3/104 showed bilateral discharge. Discharge was mucopurulent and foul smelling in the vast majority of cases. Computed tomography was required in addition to radiography in 32/104 cases to refine the diagnosis and establish a surgical treatment plan.

Thirty-six out of 104 (34.6%) cases were diagnosed as primary infectious sinusitis. In 4 of these, stenosis of the NMA was diagnosed based on CT, and 1 had a history of traumatic fracture of the frontal bone. Primary dental pathology was identified in 68/104 (65.4%) cases. Specific dental diagnostics are reported **(Table 3)**.

Surgical and postoperative data—Mean surgical time was 53.5 minutes (range, 20 to 120), with a mean volume of 0.9% NaCl of 10.6 liters (1 to 50) required to clean the sinuses from pus, inspissated pus, necrotic debris, or foreign material. After surgery, the mean number of daily sinus flushes performed was 3.1 (0 to 9), and the mean postoperative hospitalization duration was 5.56 days (0 to 12). One patient was euthanized after developing meningitis 4 days postoperatively. Eighty-seven out of 104 cases

Table 3—Details of dental pathology diagnosed as the etiology in 86 secondary sinusitis cases treated by sinoscopy or sinusotomy.

Dental pathology	Sinoscopy	Sinusotomy
Apical infection/pulpitis		
Intact crown	5	4
Secondary dentine defect	16	1
Crown fracture		
Slab fracture	13	3
Sagittal fracture	14	–
Periodontal disease		
Standard diastema	6	2
Supernumerary tooth	5	–
Patent infundibulum	1	1
Retained silicone plug	–	1
Orosinus fistula		
Postextraction	7	4
Traumatic	–	1
Dental dysplasia	–	(2)*
Dental neoplasia	–	2
Total	68	18

*The 2 dysplastic teeth also showed a clinical crown fracture for case 1 and a secondary dentine defect in case 2.

(83.6%) healed uneventfully, without complications with a mean postoperative follow-up time of 35.7 months (range, 6 to 78). Surgical site infection only developed in 1/104 cases **(Table 4)**. Nasal discharge recurred in 17/104, following a range of 21 to 120 days postoperatively (mean, 47 days). A second treatment was performed on these including repeated sinus flushing using the same technique as previously described (3/17), sinoscopy (12/17), and sinusotomy (1/17). One horse was euthanized for financial issues (1/17). At follow-up, 14 days after hospital discharge, 13/17 horses were found to be free of clinical signs after the second treatment, and 4 were kept on displaying nasal discharge. A third treatment plan was offered to these 4 patients, 1 had his sinuses flushed, 2 had a sinusotomy, and 1 was euthanized for financial issues. The 3 horses operated for the third time were free of clinical signs at follow-up after 6 months. In total, 3 horses were euthanized. The long-term outcome for this group was 101/104 successfully treated (98%).

Group 2 (sinusotomy): 26 cases

Anamnesis and diagnostics—The mean duration of clinical signs in this group of patients was 130 days, ranging from 14 to 540 days. Twelve out of 26 of patients exhibited right nasal discharge, 12/26 showed left nasal discharge, and 2/26 showed bilateral discharge. Discharge was mucopurulent and foul smelling in the vast majority of cases. Computed tomography was required in addition to radiography in 23/26 cases to refine the diagnosis and establish a surgical treatment plan.

In the sinusotomy group, 4/26 patients had a maxillary tooth extracted before presentation. Three out of 26 had a sinoscopy performed in another clinic and failed to respond to initial treatment, and 1/26 had suffered from head trauma 6 months before developing nasal discharge. Right

Table 4—Surgical data and outcome comparison between group 1 and group 2.

Parameter	All cases	Group 1: sinoscopy	Group 2: sinusotomy
Mean (range) surgical time (minutes)	59.9	53.5 (30–120)	85.5 (53–210)
Mean (range) flush volume (liters)	9.5	10.6 (5–50)	5.3 (1–10)
Mean (range) postoperative flushes	3.15	3.13 (0–9)	3.23 (1–6)
Mean (range) hospitalization time (days)	6.4	5.6 (0–12)	9.5 (3–33)
Short-term complications	8/130 (6.2%)	2/104 (0.02%)	6/26 (23%)
Long-term complications	23/130 (17.7%)	17/104 (16%)	6/26 (23%)

nasal discharge was found in 12/26 (46.2%) patients, left nasal discharge in 12/26 (46.2%), and bilateral nasal discharge in 2/26 patients (15.4%). Three out of 26 horses also exhibited headshaking, and 4/26 showed a facial swelling located either in the frontal (2/4) or the maxillary (2/4) region of the head ipsilateral to the discharge. Oral exam, endoscopy, and radiography allowed proper diagnosis in 3/26 cases. Twenty-three out of 26 horses required CT.

Primary infectious sinusitis was diagnosed in 8/26 cases, including stenosis of the NMA in 6/8 cases and the presence of dystrophic mineralization in either the rostral or the caudal maxillary sinus in 2/8 patients.

Sinusitis secondary to dental pathology was diagnosed in 18/26 horses. The specific diagnostics for the encountered dental pathology in these 18 horses are reported (Table 3). One horse was diagnosed with a large complex odontoma involving elements 210 and 211, and 1 horse was diagnosed with a compound odontoma surrounding the apex of element 208. Five horses displayed CT scan images of either dystrophic mineralizations or sinus abscesses as a consequence of dental infection.

Surgical and postoperative data—The sinusotomy approach was chosen based on the diagnostic findings. Maxillary sinusotomy was performed on 14/26 horses, concho-frontal on 8/26 horses, a caudally based single bilateral concho-frontal flap on 1/26 horses, and modified 4 X 4-cm frontal sinusotomy for SENMAP procedures in 3/26 horses. Eleven out of 26 procedures were performed on a standing sedated horse, 15/26 procedures were performed under general anesthesia, and 3/15 of these were started on standing and finished under general anesthesia when sufficient analgesia and patient cooperation could not be achieved.

The mean surgical time was 85.5 minutes (range, 53 to 210) with a mean volume of NaCl 0.9% of 5.3 liters (range, 1 to 10) used to rinse the sinuses. Sinus hemostatic bandages had to be introduced in 11/26 horses. The mean number of postoperative sinus flushes was 3.23 (range, 0 to 6), and the mean duration of postoperative hospitalization was 9.5 days (range, 3 to 33). A single surgical treatment was successful with horses discharged from the hospital free of nasal discharge and no subsequent relapse in 20/26 horses (77%) with a mean postoperative follow-up time of 25.3 months (range, 6 to 78).

Six out of 26 horses developed short-term complications including surgical site infection limited to the rostral corner of the sinusotomy (all resolved with wound care) in 5/6 cases and fronto-nasal suture periostitis in 1/6 case (also resolved). Six out of 26 horses developed long-term complications with no resolution of initial clinical signs after discharge. These had to undergo a second treatment, which consisted of sinoscopy in 2/6 horses, a second sinusotomy in 2/6 cases, and conservative treatment in 2/6 cases (sinus flush and medical treatment). After the second treatment, all 6 horses were free of clinical signs at long term follow-up. These numbers are reported (Table 4).

Overall outcome

A single treatment resulted in long-term resolution (range 6 to 78 months) of clinical signs in 82.3% of cases (107/130). Following a second (19/130) or a third (2/130) treatment, 98.5% (128/130) of referred horses suffering from primary infectious sinusitis or dental-related sinusitis were successfully treated. Two horses had to be euthanized. The mean number of postoperative flushes was 3.15 with a mean duration of hospitalization before discharge of 6.4 days. Six out of 130 (4.6%) horses suffered from a surgical site infection.

Discussion

This large case series displays results obtained after surgical treatment of referred chronic sinusitis cases that have been treated, in some cases, for more than 2 years without results. To be able to understand and treat such cases, a complete diagnostic workup needs to be performed, including physical examination, nasal endoscopy, dental examination, and medical imaging diagnostics.

This study shows that thorough debridement of chronic primary or dental-related sinusitis through a frontal sinoscopic portal or an osteotomy flap approach can lead to a good long-term outcome in 83% of cases following the first treatment. This includes simple aftercare and minimal surgical site infection (overall 4.6%).

When severe hemorrhage was encountered peroperatively, hemostasis by compression was achieved by packing the sinuses with gauze bandages that were passed through the ventral conchal wall with the help of a narrow nasogastric tube, toward the nose. These bandages were removed by traction of the nasal end of the bandage 48 to 72 hours postoperatively, avoiding opening the flap again as proposed by Hart and Sullins[15] In the authors' opinion, this might help to limit osteotomy surgical site infections. The method to ensure sinonasal hemostasis proposed by Melly and Baia,[16] inserting an endotracheal tube through the nose and distending the balloon at the hemorrhage site, is promising. It would avoid leaving bandages in the sinuses, which could provide a perfect environment for bacterial growth and thus enhance surgical site infection. However, this method was never used in the presented cases.

Sinoscopic debridement and lavage of infected compartments, performed in 104/130 (80%) cases, was the first choice of treatment. It was associated with fewer short-term postoperative complications compared to sinusotomy, 1/104 (0.9%) and 6/26 (23%), respectively. However, horses treated by sinusotomy suffered from more severe pathologies that could have been responsible for this larger number of postoperative complications.

Persistent infection following sinus surgery was less encountered in the present study than previously described[2] with only 23/130 cases (17.7%) displaying continued nasal discharge. The overall response including horses that required a second and a third treatment was excellent (98.5% success). However, the present study does not include anything but primary and dental secondary diseases.

Recent alternative oral extraction techniques such as minimal invasive transbuccal screw extraction[17] and dental sectioning have helped to reduce invasive dental extractions, and partial coronectomies[18] have helped reduce transsinusal repulsions for exodontia. Ramzan et al[19] showed that endoscopic guidance during the extraction of fractured cheek teeth facilitates the placement of instruments and the oral removal of fractured cheek teeth in horses. Nevertheless, in a few of our cases, where the clinical crown or the roots are dysplastic, for large complex odontomas, more invasive procedures could not be avoided, thus creating an oro-sinusal fistula (OSF) described as a macroscopic communication between mouth and sinus. Out of 25 OSF 11 were iatrogenic and a complication of a maxillary cheek tooth extraction. Caramello et al[20] found out that regardless of the exodontia technique used, OSF would occur in 10% of cases. In a comparable study, Kennedy et al[21] showed that OSF can happen in 0.9% of cases but that the most common complication encountered after cheek teeth extraction was alveolar bone sequestration including alveolar infection (in 7.5% of cases). This complication could lead to either secondary sinusitis or OSF if the tooth extracted has an anatomical relationship with the floor of 1 of the maxillary sinuses.

When OSF is present, and sinusitis present, sinusitis should be treated, but despite its challenges, OSF should be addressed too. Managing OSF can be done by multiple techniques such as laviator nasolabilalus transposition, polymethylacrylate alveolar packing, etc.[22]

Rare complications also occur after sinus surgeries, such as suture periositis and bacterial meningitis. One case developed a frontonasal suture periostitis after infection of the concho-frontal osteotomy bone flap. Verwilgen et al[23] showed that in 104 cases of suture periostitis, 48 developed facial swelling after a maxilla-facial surgery procedure and 8 following sinus disease. Although rare, owners should be aware that these complications can happen. One case developed bacterial meningitis after sinoscopic treatment. This complication is rarely met. Bach et al[24] described 5 cases of horses that developed neurological signs after sinus surgeries and that were diagnosed with bacterial meningitis. These horses were diagnosed with a variety of sinus pathology. Due to the very limited number of such reported cases, the exact etiopathogenesis of meningitis following sinus surgery or disease remains unknown. Although extremely exceptional, every patient surgically treated for sinonasal disease should be monitored accordingly.

Sinus drainage is key to successfully treating sinonasal disorders. Tatarniuk et al[25] have provided a better understanding of the anatomy of the sinonasal communication or NMA. Brinkschulte et al[26] have provided 3-D renderings of the NMA and concluded that these could provide a useful basis to maintain or reconstruct the normal anatomy of sinonasal communication by surgical intervention to resolve sinus diseases. The anatomy of the sinonasal communication can be altered by the chronicity of sinus disease. Different surgical techniques have been described to restore sinonasal drainage. The sinonasal communication can be enlarged with an endoscope-guided balloon as described by Tatarniuk et al.[27] Dixon et al[3] used a narrow plastic tube passed through the sinonasal communication and left in situ for several days with good results. More recently, Carmalt et al[28] described the possibility of depressing the maxillary septal bulla to improve sinus drainage while avoiding epistaxis. Some cases that feature complete stenosis of the sinonasal communication require a large surgical reconstruction. Bach et al[14] described 2 different surgical techniques that can be used either separately or combined to improve sinus drainages in horses. In the present study, 4 horses diagnosed with chronic primary sinusitis and stenosis of the sinonasal passages were successfully treated using the SENMAP technique. However, the surgical approach was modified, creating a 4 X 4-cm square frontal osteotomy bone flap centered on the landmarks described instead of a 35-mm Galt trephine. Enlargement of the sinonasal communication was created with the help of a vessel sealing device (Ligasure) avoiding the need for transnasal conchotomy and associated possible hemorrhage.

Radiography is still the most widely used medical imaging modality for sinus disorders imaging. More and more facilities are equipped with high-quality fan-beam CT Scanners and can perform the acquisition of high-quality imaging studies on standing sedated horses. In 2015, Manso Diaz et al[29] showed that CT had a higher sensitivity and specificity to diagnose dental pathologies and that compared to CT radiographic identification of sinus involvement was less sensitive, particularly for ventral conchal and sphenopalatine sinuses, and presented an overall sensitivity and specificity of 43.5% and 16.7%, respectively. This can lead to surgical planning errors and thus to postoperative complications. Computed tomography gives higher resolution and 3-D imaging of the complex sinus anatomy and has helped to better understand sinus diseases, thus helping surgeons to better apprehend them and to find the best treatment option for each case. However, the interpretation of CT images can sometimes be a challenge with respect to the identification of the nature of radiopaque structures. Differentiating between swollen inflamed mucosa, thick pus, pseudomembranes, and cyst-like lesions using the calculation of Hounsfield units can be inaccurate. After having evaluated the sinus compartments of 4 cases operated with sinusotomy, these cases could have been treated with sinoscopy as well, when, for example, soft tissue attenuation, which appeared to be a mass on CT, was mismatched with thickened mucosa or thick fluid.

Headshaking was found to be the main complaint in 3 of our patients. In a recent study, Fairburn et al[30] reported that 3/101 horses investigated for headshaking with the help of CT were diagnosed with apical infection of a maxillary cheek tooth. Even more recently, Labbe et al[31] investigated the prevalence of headshaking in horses affected by primary and secondary dental sinusitis with modifications of the infraorbital canal anatomy. A total of 65/66 cases displayed anatomical modification of the infraorbital canal, but only 5 of these horses showed headshaking signs despite modifications of the infra-orbital canal anatomy. This correlates with the results from Edwards et al,[32] who showed that only 9% of horses displayed headshaking despite 45% displaying anatomical modifications of the infraorbital canal. Two of our patients were free of headshaking clinical signs after sinusitis surgical treatment, and 1 is still headshaking. No postoperative headshaking signs were encountered as described by Gilsenan et al.[33]

Alternative techniques to assess and treat sinusitis have been described. Morello et al[9] described laser vaporization of the dorsal turbinate to access and evaluate the paranasal sinuses of horses, with the limitation of preoperative hemorrhage and not being able to access compartments in case of thickened mucosa. Transendoscopic conchal fenestration that allows access to sinus compartments via the contralateral nostril as described by Kološ et al[10] has the same limitations. Although these techniques allow access to sinuses, they could be insufficient to debride large quantities of inspissated pus, food debris, or necrotic material in a single-step surgery. These procedures also require advanced and specialized surgical material, not always easy to acquire.

It is, to the authors' knowledge, the first-time postoperative care after sinus surgery is described with no Foley catheter in situ to flush sinuses. Simple postoperative care without the use of a Foley catheter in situ to rinse the sinuses through the surgical wound of the frontal portal for sinuscopy or placed in a corner of the osteotomy bone flap as described in previous studies is an efficient technique for postoperative care. However, the authors prefer to use single daily sinus flushes with 1 liter of sterile 0.9% NaCl using a 16-gauge needle inserted through the skin next to the sinoscopic surgical incision or through a predrilled trephination hole in the bone flap. The present study proved this to be an efficient and less time-consuming postoperative treatment, without any further endoscopic reexamination of the sinuses as part of the initial treatment plan as described in previous studies.[3] Not leaving a Foley catheter, which acts like a foreign body, and not opening a second time the surgical wound as previously described may have contributed to the low number of wound infections. It also reduces the stress and discomfort that accompany other flushing procedures.[3,4] Only 1/104 of patients treated by sinoscopy developed a surgical wound infection, which is lower than described following Foley catheter use.[3] Postoperative sinus lavages are debatable. Our study did not have a control group with no postoperative sinus lavage. Therefore, we could not conclude if postoperative lavages are a necessity or not. Further study would be necessary.

A total of 86/130 (66.2%) sinusitis cases included in this study were caused by dental problems. All these diseased teeth were extracted. Overall dental knowledge, available ancillary techniques, and diagnostic and treatment methods have tremendously progressed throughout the past 20 years (Dixon).[34] The use of dental endoscopes introduced in the early 2000s by Griss[35] and Tremaine,[36] including large cohort studies (Simhofer),[37] has also changed the quality of dental pathology diagnostics compared to dental mirrors. Chiero et al[38] showed that dental endoscopy had a superior sensitivity to detect any dental pathology compared to mirrors (83% vs 39%). Oral endoscopy helps in the early diagnosis of less obvious clinical signs such as secondary dentine defects, diastemata, infundibular caries, etc. If present on a caudal maxillary cheek tooth, a secondary dentine defect could be the clinical sign of pulpitis, which could be the primary cause of secondary sinusitis. These pulpitis can now be addressed and treated as shown by Lundström et al[39] in selected cases. Deep periodontitis between caudal maxillary teeth can lead to OSF. In our study, 13/86 cases (15%) of OAF were caused by deep periodontitis, often underdiagnosed for a long period of time. A better understanding of the infundibulum anatomy of infundibulum hypocementhosis etiopathogenesis of infundibulum relationship to the other dental tissues such as pulp (Horbal et al)[40] and of infundibulum caries treatment with excellent outcomes as shown by Pearce and Brooks[41] could reduce the prevalence of dental pathologies and thus the prevalence of secondary dental sinusitis.

Meticulous diagnostic and thorough surgical debridement of diseased sinuses affected by primary sinusitis and dental secondary sinusitis help to minimize the aftercare and lead to good long-term outcomes. When possible, sinoscopy should be preferred over sinusotomy, even though in some cases, more invasive surgery cannot be avoided.

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