EQUINE VETERINARY EDUCATION
Equine vet. Educ. (2001) **13** (5) 265-273

Tutorial Article

Diagnosis of conditions of the paranasal sinuses in the horse

W. L. BEARD AND J. HARDY
The Ohio State University, Department of Veterinary Clinical Sciences, 601 Vernon L. Tharp Street, Columbus, Ohio 43210, USA.

Introduction

Diseases of the paranasal sinuses are common in equine practice and persistent unilateral nasal discharge the most common clinical sign, usually causing owners to seek veterinary advice. The nasal discharge is usually self limiting or improves following antibiotic therapy, with the result that antibiotic therapy is frequently substituted for a diagnosis. A physical examination and appropriate diagnostic procedures are, therefore, not performed until antibiotic therapy has failed to resolve the condition. This approach usually causes no harm; however, facial and nasal passage deformity may worsen if treatment is delayed for expansile masses in the sinus. **A preferred approach is to diagnose accurately the condition and implement appropriate treatment**. More treatment options are available and fewer complications and less deformity result if the conditions are diagnosed early (Lane 1993; Trotter 1993).

Sinus disease should be suspected if there is a nasal discharge or evidence of deformity of the bones overlying the sinus. When nasal discharge is present, the first step is to identify the origin. Routine endoscopic examination is sufficient to localise the source of the discharge to the paranasal sinuses by observing the discharge originating from the nasomaxillary aperture. An intermittent discharge may not be present at the time of examination; however, the sinus can be tentatively identified as the source, if the trachea and guttural pouches are examined and ruled out as the source of the discharge. Facial deformity over the sinuses that accompanies the nasal discharge is strongly suggestive of sinus involvement. Once the disease process has been localised to the paranasal sinuses, several differentials become likely (**Table 1**)

The case details, history and findings from the physical, endoscopic and subject radiographic examinations can be combined to arrive at a diagnosis and institute appropriate therapy. **The purpose of this paper is to discuss separately each of the components of the diagnostic process to enable the practitioner to recognise the findings suggestive or typical for each of the sinus conditions**. **It is important to remember** that there may be considerable overlap between the various conditions, such that a specific diagnosis is not apparent when any component of the diagnostic process is considered separately. **When all diagnostic criteria are combined, the diagnosis can be made easily with a high degree of certainty**.

Fig 1: Purulent nasal discharge present at the nares.

History

The owner or trainer is usually a reliable source of the relevant historical information. **The owner's**

Fig 2: Haemorrhagic nasal discharge.

observations are usually correct, although their interpretations may be erroneous. **Historical information should be obtained for** the nasal discharge, facial deformity, exercise intolerance, prior illnesses and previous therapy. An accurate chronology of the clinical signs should be strongly suggestive of the various conditions.

The onset, character and odour of any nasal discharge should be determined. The character of the discharge may not be constant; therefore, the owners should be asked if the discharge has always been of the same colour, viscosity and odour. The time of onset and rate of progression of any facial swelling or deformity should be determined.

Owners should be questioned about the presence of any respiratory noise. Although it is not possible to localise the source of an upper airway noise without endoscopy, there are certain characteristics of the noise which, if present, would be compatible with one of the sinus conditions. **Sinus masses or airway narrowing** resulting from sinus deformity are all space-occupying masses and result in a fixed airway obstruction.

A noise resulting from a fixed airway obstruction should be present on both inspiration and expiration and should also be consistent from day to day, such that the same intensity of exercise always produces the noise. Respiratory noises that are not consistent with a fixed respiratory obstruction are probably evidence of a second problem unrelated to the sinus. Respiratory noise that is present at rest is the result of severe airway narrowing that should be readily evident upon endoscopic examination

The owner should be questioned concerning prior respiratory disease affecting this horse or other horses on the premises. Viral or bacterial respiratory diseases may occasionally result in sequelae such as sinusitis or inspissated pus in the ventral conchal sinus which are almost invariably unilateral. In these cases, the inciting respiratory disease begins as a bilateral nasal discharge that becomes a unilateral discharge as sinusitis develops and the initiating, more generalised, respiratory disease resolves. Prior respiratory disease is a predisposing cause for bacterial sinusitis and inspissated pus in the ventral conchal sinus; for the other conditions it is a confounding coincidence.

A knowledge of the response to prior antibiotic therapy is useful. Any condition which results in obstruction of the nasomaxillary orifice may result in a secondary bacterial infection which may temporarily respond to antibiotics. Nasal discharge may decrease in volume and become less purulent following antibiotic administration, because at least some of the discharge is attributable to a primary or secondary bacterial infection. **Recurrence of the clinical signs following discontinuation of antimicrobial therapy should be construed as evidence for the need to further evaluate the condition**.

Antibiotic therapy can reasonably be expected only to improve or ameliorate the clinical signs attributable to infection. However, all of the clinical signs may not be attributable to an infectious process. Facial deformity,

TABLE 1: Key findings with conditions of the paranasal sinuses

Condition	Character of the nasal discharge	Deformity and location	Oral examination findings	Radiographic findings
Primary sinusitis	Purulent	None	Normal	Variable amount of free fluid in sinus. Possible filling of the ventral conchal sinus.
Sinusitis secondary to dental disease	Purulent, malodorous	None	Gingivitis, broken or malaligned teeth, draining tracts adjacent to teeth	Loss of *lamina dura*, sclerosis and lysis around affected tooth, free fluid and soft tissue opacity centred over affected tooth
Trauma	Haemorrhagic	Depression fractures, soft tissue swelling, tissue gas crepitus. Soft tissue swelling may obscure the fractures.	Normal	Depression fractures, soft swelling, free fluid in sinus
Sinus cyst	Clear-yellow, viscous, no odour, occasionally purulent	Maxilla rostral to the eye. Frontal bone infrequently. Maxilla may become malleable in long standing cases. Airflow usually diminished on affected side	Normal	Soft tissue opacity of sinus, sinus may be expanded beyond normal borders. Summation soft tissue densities as cyst expands and fills multiple sinus compartments
Ethmoid haematoma	Sanguinous	Infrequent. Frontal bone deformity if present, airflow diminished in severe cases	Normal	Soft tissue mass of variable size usually originating from the ethmoid turbinates
Neoplasia	Purulent, sanguinous, malodorous	Maxilla, lacrimal bone, exophthalmos, frontal bone, diminished airflow is variable depending on expansile nature of lesion	May have mucosal erosion of hard palate, loose teeth, mass may be visible	Soft tissue or bony mass in sinus, mineralisation of soft tissues, bone destruction evident in bony septae in sinus or maxilla

respiratory stridor and exophthalmos result from the expansion of space-occupying masses and progress in spite of antimicrobial therapy. Owners may not usually notice this distinction and erroneously report improvement with antibiotics. Owners are able to provide the necessary information regarding the progression of other signs **if the proper questions are asked**.

Case subject details

Patient age can be suggestive although never specific for any individual disease. **Epithelial neoplasia** is the most common type to develop in the sinus and occurs most commonly in aged horses. **Osseous tumours** of the sinus may develop in younger horses (Dixon and Head 1999). Paranasal sinus cysts present typically in horses less than age 2 years and in those age 10–14 years (Cannon *et al.* 1976; Lane *et al.* 1987a; Trotter 1993). **No other strong correlations with age are apparent**. Reported breed incidence of the various conditions is in most instances a reflection of hospital populations. **Ethmoid haematomas** appear to be more prevalent in Thoroughbred and Thoroughbred cross horses and have never been reported in Standardbreds (Cook and Littlewort 1974; Bell *et al.* 1993). Otherwise, breed predilections for any of the conditions have not been established and are not of any diagnostic significance.

Physical examination

Nasal discharge

The colour, consistency and odour of a nasal discharge are helpful in distinguishing between the various sinus diseases. All of the conditions discussed here may occur bilaterally; however unilateral disease is most common (Gibbs and Lane 1987; Bell *et al.* 1993; Schumacher and Honnas 1993; Trotter 1993). A purulent discharge with foul odour characteristic of anaerobic bacteria is most suggestive of a **tooth root infection or neoplasia** (**Fig 1**).

A clear or yellow, viscous discharge is suggestive of a sinus cyst. The nasal discharge resulting from a sinus cyst usually begins as a clear fluid and becomes secondarily infected resulting in a more purulent discharge. With antibiotic therapy, the discharge becomes clear again but does not cease. This discharge still lacks the putrid odour typical of anaerobic bacteria.

A **sanguinous nasal discharge** originating from the sinuses is the result of trauma to the sinus, an ethmoid haematoma or neoplasia (**Fig 2**). **The character of the nasal discharge** associated with the various conditions affecting sinuses are listed in **Table 1**.

Facial deformity

Distortion of the facial bones may occur with some of the diseases and can be helpful to distinguish among the various conditions (**Table 1**). Deformity occurs in the bones overlying the maxillary and frontal sinuses and is the result of an expansile mass contained within the sinus (**Fig 3**) Distortion of the sinuses medially occurs as well and probably precedes the outward expansion of these masses because the medial border of the sinuses and nasal turbinates are thinner bones that are more easily deformed. The internal bony expansion requires endoscopy for direct observation and will be discussed in the endoscopy section. Decreased airflow through one nares and respiratory noise are findings indicative of deformity of the nasal passages. Decreased airflow can be detected by the examiner holding a cupped hand in front of the nares to compare airflow from both sides of the nasal passages. Periapical infections of teeth located within the sinus and bacterial sinusitis rarely result in deformity of the bones. Facial deformity of the bones overlying the sinus commonly indicates a sinus cyst or neoplasia. The roots of upper premolars 2 and 3 and the rostral root of premolar 4 are encased within the maxilla. Infection of these tooth roots results in osteomyelitis and a bony lump on the face. Therefore, the deformity does not overly the sinuses nor is nasal discharge typically present. Ethmoid haematomas do not usually result in facial deformity. Rarely, an exceptionally large ethmoid haematoma may cause outward bulging over the frontal or maxillary sinus (**Fig 4**). Expansile masses cause bone resorption and the maxilla and frontal bones overlying the sinus may become soft and rubbery in texture. Exophthalmos is caused by a retrobulbar mass and is almost always indicative of neoplasia (**Fig 5**).

Examination of the oral cavity

Examination of the oral cavity is essential in differentiating between diseases of the sinus (Schumacher and Honnas 1993) and is most easily performed in the sedated patient with an oral speculum in place. The mouth should be thoroughly rinsed with water to remove feed material and both manual and visual examination should be performed. Adequate illumination and retraction of the tongue are required and **particular attention should be paid to the last 4 cheek teeth as these are the teeth that have all or some portion of their apices within the maxillary sinus**.

The dental arcades should be inspected for loose, broken, or absent teeth and teeth examined for abnormal wear. **Extreme wave or step mouths** may wear affected teeth down below the gum line resulting in periodontitis and ascending infection to the apex of the tooth. The **gingiva around the teeth** should be inspected to ascertain that it is firmly adherent to the teeth. Separation of the oral gingiva around a tooth is strongly suggestive of a problem with that tooth.

Occasionally, a draining tract may be identified next to a tooth indicating a problem with that tooth and the discharge usually has the same odour as the nasal discharge. Loose, broken, misshapen, and absent teeth are suggestive of sinusitis secondary to dental disease provided that the affected teeth have their apices in the

Fig 3: Bony deformity over the maxillary sinus in a foal with a paranasal sinus cyst.

Fig 4: Frontal bone deformity from a large ethmoid haematoma.

maxillary sinus. Although the aforementioned changes may be present in some cases; **the majority of horses with sinusitis secondary to dental disease exhibit no abnormalities on oral examination**. Periapical infection is usually an isolated occurrence with involvement of a single tooth.

Malignant neoplasms of the sinuses are frequently invasive and may present evidence of abnormalities on oral examination. Changes include; erosive lesions of the mucosa of the hard palate and one or several teeth may have separation of the gingiva, loosening or, be deformed (**Fig 6**). Multiple tooth involvement is common with neoplastic diseases.

Endoscopy of the upper airway

Upper airway endoscopy is indicated as the first

Fig 5: Maxillary sinus deformity and exophthalmos in a horse with squamous cell carcinoma of the sinus.

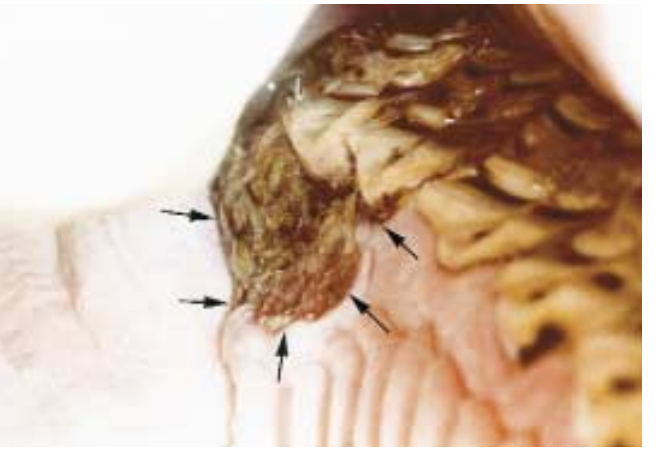

Fig 6: Oral mucosal ulceration adjacent to upper molar 3 from erosion of a squamous cell carcinoma in the maxillary sinus.

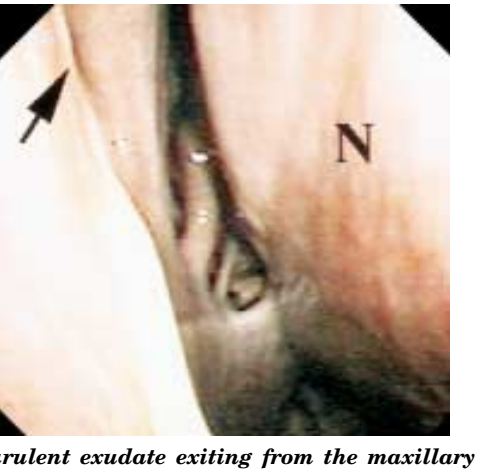

Fig 7: Purulent exudate exiting from the maxillary sinus into the nasopharynx via the nasomaxillary aperture (arrow). N = nasal septum .

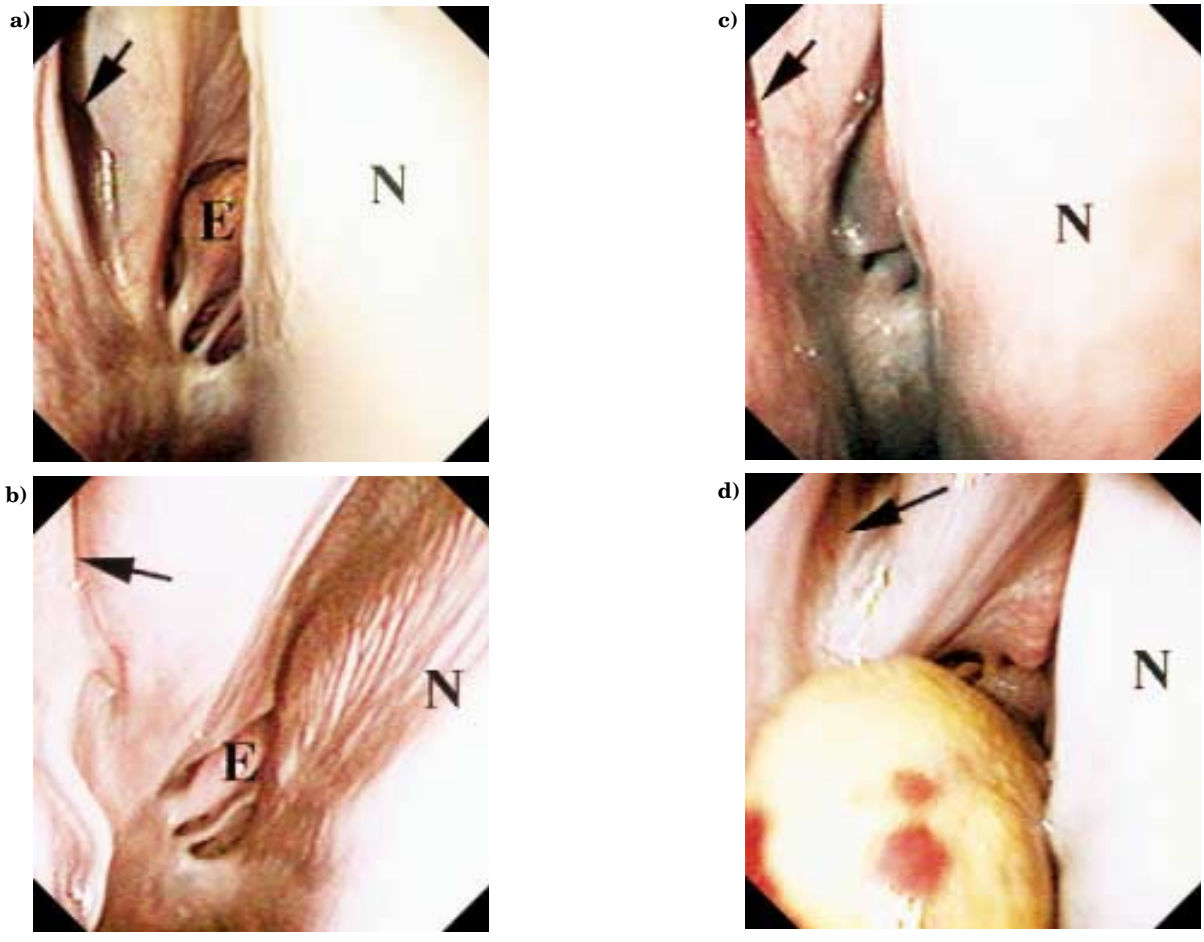

Fig 8: Endoscopic views of the right caudal nasal passage demonstrating: a) the normal appearance of the nasal septum *(N)*, ***nasomaxillary opening*** *(arrow) and* ***ethmoid turbinates*** *(E);* ***b) nasomaxillary opening is occluded due to an expansile maxillary sinus cyst causing compression of the opening. Note*** *the stream of white viscous exudate leaking from the aperture;* ***c) an expansile mass from the opposite sinus is deviating the nasal septum to the right,*** *partially obscuring the view of the ethmoid turbinates;* ***d) ethmoid haematoma protruding from the turbinates and obscuring the view of the normal ethmoid turbinates.***

diagnostic step following a physical examination. **Endoscopy is necessary to confirm** that the nasal discharge is in fact originating from the sinuses and to rule out other sites, such as the guttural pouches or trachea as its source. **Identification of an exudate originating from the nasomaxillary aperture is sufficient evidence to establish the sinus as the source of discharge** (**Fig 7**). Endoscopic examination of the sinus is possible only in rare instances in which horses have an abnormally large nasomaxillary aperture or have undergone prior sinus surgery that allows an endoscope entry into the sinus.

Much more information can be obtained from the endoscopic examination than simply the confirmation of the sinus as the source of the discharge. **Distortion of the nasomaxillary opening** occurs because of expansile masses and is suggestive of a sinus cyst or neoplasia (**Fig 8b**).

Narrowing of the nasal passages is a very subtle finding that is often overlooked unless the clinician specifically looks for it. The narrowing may occur in any portion of the nasal passages but **often goes undetected** because the examiner uses only the ventral meatus to insert the endoscope (**Fig 8c**). To avoid this error, the ventral, middle, and dorsal nasal meatus should each be examined separately. **Both nasal passages should be examined for comparison** to enable detection of subtle changes. Distortion of the nasal passages or nasomaxillary aperture accompanying sinus disease should also be construed as evidence of an expansile mass such as an ethmoid haematoma, sinus cyst, or neoplasia. **Sinusitis, either primary or secondary to dental disease, rarely results in deformity**.

Ethmoid haematomas are usually evident on endoscopic examination of the turbinate region; they may originate in the sinus and protrude into the nasal passages in this region (**Fig 8d**). The portion of the ethmoid haematoma that is visible in the nasal passages is smooth, rounded, and may vary in colour to include shades of green, yellow, red or purple. The ethmoid turbinates may be completely obscured by the masses. Infrequently, an ethmoid haematoma resides entirely

Fig 9: Lateral radiograph of skull of a horse with maxillary sinusitis. *A fluid line is present in the sinus (arrows).*

within the maxillary sinus without extension into the nasal passages. The sanguinous nasal discharge and other clinical signs will still be present.

Neoplastic masses may be visible on endoscopic exam as masses protruding from the sinus opening.

Skull radiography

Skull radiographs are essential for a definitive diagnosis of sinus disease. Radiographs must be **properly positioned** and of **good quality**. Endoscopic examination has already confirmed that the region of interest is the sinuses so radiographs may be centred over the sinus region. **Radiographic examination should consist of at least 4 views**; a straight lateral, obliques of each side, and a dorso-ventral view (Gibbs and Lane 1987; Park 1993). **Oblique views of both the left and right sinuses are important to compare for subtle changes in bone density around the tooth roots**.

Primary sinusitis is characterised by fluid opacity of the maxillary sinuses (**Fig 9**). The fluid line is confined within a normally shaped maxillary sinus. Soft tissue masses are easily differentiated from free fluid because a soft tissue mass will have an irregular outline; whereas the free fluid forms a gravity dependent, straight line, fluid-air interface and is visible on standing lateral or oblique radiographs. The above is true unless the sinus is completely filled by a soft tissue opacity, in which case it may be difficult to distinguish between a mass and free fluid filling the sinus. There is no evidence of bone lysis, production, or sclerosis and there are no soft tissue masses within the sinus unless

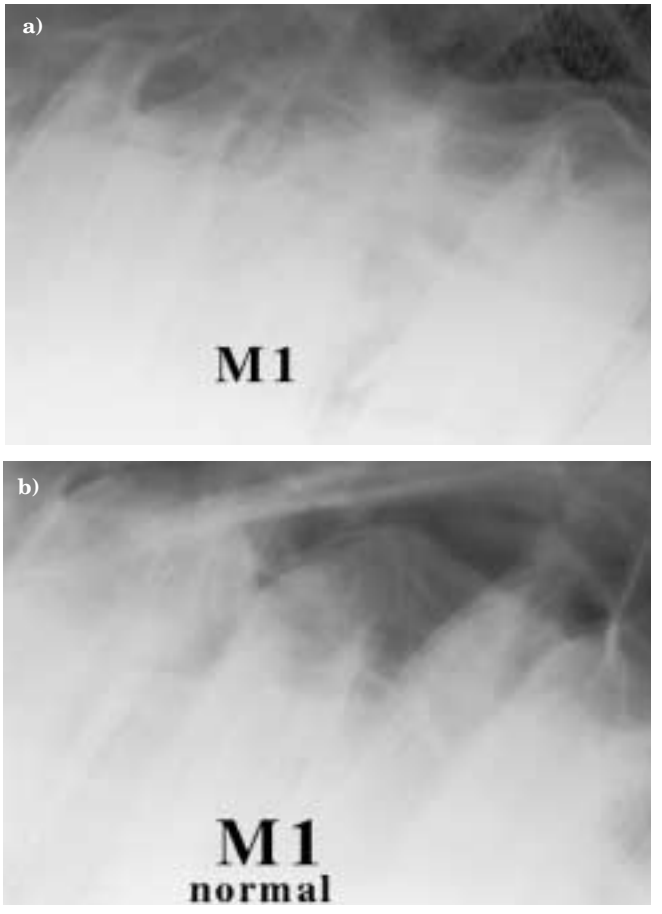

Fig 10: Apical tooth root abscess of molar 1. a) *Lysis and sclerosis centred over the root of M1.* ***b)*** *Opposite normal side for comparison.*

the sinusitis is complicated by inspissated pus in the ventral conchal sinus.

Sinusitis is occasionally complicated by inspissated pus in the ventral conchal sinus. This will be most evident on the dorsoventral radiographic projection as a soft tissue opacity filling the medial border of the sinus that extends further rostrally than the typical border of the maxillary sinus adjacent to premolar 4 (Schumacher *et al.* 1987). The soft tissue opacity obscures the view of the air-filled nasal passages adjacent to the nasal septum.

Radiographic findings that support a diagnosis of tooth root infection include; bone sclerosis and lysis centred over the affected tooth apex, loss of the *lamina dura*, and lysis of the normal contour of the tooth root. Inflammatory exudate may be present in the sinus as free fluid and irregular soft tissue opacity in the floor of the maxillary sinus over the affected root (Lane *et al.* 1987b; Park 1993). The bone reaction is limited to the affected tooth however the free fluid and inflammatory debris within the sinus may be much more extensive.

Oblique radiographic views of the sinus are essential for diagnosis of dental disease. It is

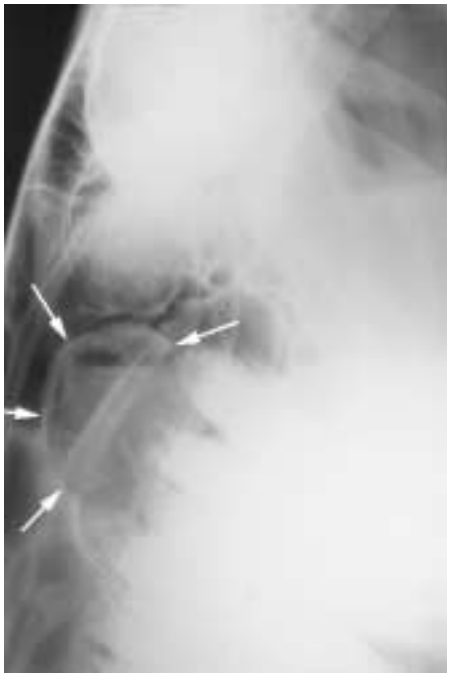

Fig 11: Lateral skull radiograph demonstrating a well circumscribed paranasal sinus cyst (arrows) in the maxillary sinus.

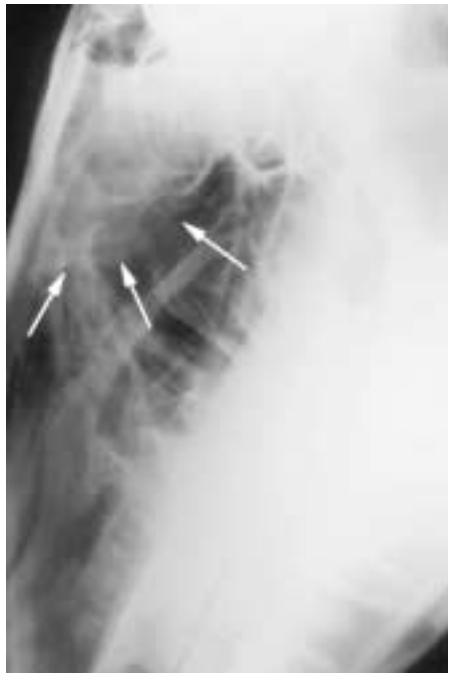

Fig 12. Lateral radiograph of the skull. *An ethmoid haematoma (arrows) is evidenced by a soft tissue mass originating from the ethmoid turbinates.*

necessary to compare radiographs of the apical portion of the suspected tooth from the affected and normal sides (**Fig 10**). **This comparison enables a much easier diagnosis than reliance on views of the affected side only**. The soft tissue opacification may obscure accurate identification of the tooth root outline. This may make the examiner question the viability of adjacent teeth.

Trauma to the bones overlying the paranasal sinuses results in soft tissue swelling, depression fractures, and free fluid within the sinus. **Subtle fractures may be very difficult to detect radiographically**.

Paranasal sinus cysts are usually evidenced by complete fluid opacification of the maxillary sinus (**Fig 11**). **Cysts usually have a smooth contour and are oval or round**. The normal rostral limit of the maxillary sinus usually extends to the caudal root of PM4. Paranasal sinus cysts are often expansile and the mass will be seen to expand the sinus beyond it's normal margins. This is evidenced by fluid opacification rostral to the caudal root of PM4 on a lateral radiograph. Paranasal sinus cysts expand medially as well resulting in the medial wall of the sinus being displaced toward the nasal septum. This is evident on dorsoventral radiographs of the head as the fluid opacity from the sinus mass overlaps and may cause deviation of the nasal septum toward the opposite side. Some sinus cysts may have a mineralised capsule.

A soft tissue opacity appearing to originate from the ethmoid turbinates on a lateral or oblique view is suggestive of an ethmoid haematoma (**Fig 12**). An ethmoid haematoma often gives the appearance of being suspended within the sinus. The rostral border of the haematoma is usually rounded and the caudal border is indistinct as

Fig 13. Dorsoventral skull radiograph. *A neoplastic soft tissue mass within the maxillary sinus (3 arrows) is deviating the medial wall of the sinus and overlapping the nasal septum.* ***Note*** *the bone lysis of the maxilla (2 arrows) and destruction of normal sinus septae on the affected side.*

the mass blends with the silhouette of the ethmoid turbinates. The masses may occasionally be large enough to be confused with sinus cysts; however a sinus cyst

Fig 14: Collection of fluid from the maxillary sinus for bacterial culture and cytology. a) *Steinmann pin trephination of the maxillary sinus using a Jacob's chuck and 4.8 mm trocar point pin.* ***b)*** *Polyethylene tubing inserted into the sinus for sample collection.*

usually results in soft tissue opacity completely obscuring the ventral border of the sinus. **Small ethmoid haematomas may be difficult to detect radiographically. Appropriate radiographic exposure is necessary to demonstrate these masses within the sinus**. Overexposure may result in the masses not being detected.

Neoplastic diseases involving the sinus are characterised by the presence of a soft tissue or bony mass in the sinus (**Fig 13**). **Radiographic findings that are suggestive of a neoplastic process include**; bone destruction, osseous proliferation, and mineralisation of soft tissues. Bone destruction is recognised by loss of the

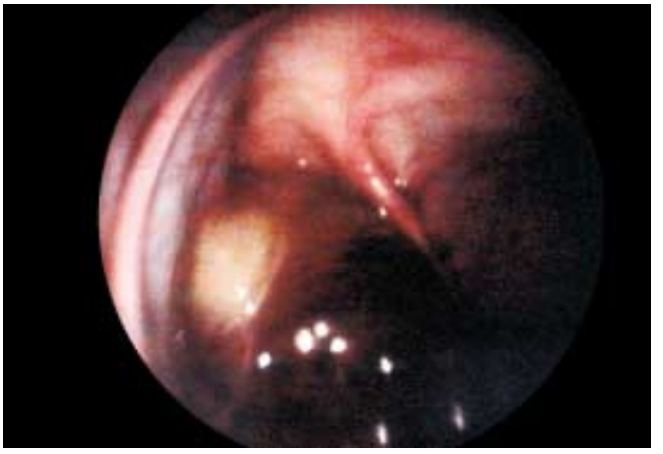

Fig 15: Sinoscopy of the paranasal sinuses. *A small ethmoid haematoma is present ventral to the ethmoid turbinate.*

bony trabeculae within the sinus as well as bone loss from the maxilla when viewed from a dorsoventral radiograph. The radiographic changes with neoplasia may resemble a tooth root abscess and neoplasia should be suspected if there is involvement of more than one tooth. Exophthalmos, even when prominent on gross inspection, is difficult to appreciate on radiographs because of the difficulty in isolating this area.

Ancillary diagnostics

Fluid and tissue samples from the sinuses may be necessary to confirm a diagnosis. Bacterial culture and sensitivity, cytology and histopathology may be performed on samples obtained by a minimally invasive technique. Collection of samples is easily accomplished in the standing patient via trephination of the sinus with a Steinmann pin (**Fig 14**). The size of the Steinmann pin required will depend on the method of sampling. Steinmann pin portals into the sinus may be made in sizes from 1.6 mm up to 9.0 mm in diameter without a cosmetic blemish (Ruggles *et al.* 1991, 1993; Worster Hackett 1999). A pin size should be chosen that is slightly larger than the sampling instrument to be used. Local infiltration with lidocaine results in sufficient analgesia to permit trephination of the sinus. Fluid samples for Gram stain, bacterial culture, and cytology may be obtained with a long needle or polyethylene tubing inserted into the sinus through the trephine hole.

The most common bacterial isolate from the sinus with a primary bacterial sinusitis is *Streptococcus* sp. **Usually a primary sinusitis yields a pure culture**. Tooth root infections often result from communication with the mouth. In these cases, Gram stain and culture yields a mixed population of bacteria. This has been reported to be helpful in distinguishing between the 2 conditions (Schumacher and Honnas 1993).

Solid masses may be sampled via a variety of techniques. **The simplest and least invasive method**

is to perform a fine needle aspirate. The aspirated material is fixed on a microscope slide and stained for cytology. Core samples of a solid tissue mass may also be obtained with a 14 gauge biopsy instrument (Tru-Cut biopsy needle)[1]. Impression smears of the samples thus collected may be stained immediately to examine for the presence of neoplastic cells. Samples should also be submitted for histopathology. Larger tissue samples or samples of bony masses may be obtained with arthroscopic rongeurs introduced into the trephine hole.

The above procedures are performed blindly using radiographs for orientation to direct the placement of the sampling instruments. In the majority of instances, blind sampling is sufficient to obtain a representative sample. Occasional instances arise where direct visualisation of the sinuses facilitates a diagnosis.

Endoscopy of the sinus

Sinus endoscopy via the nasal passages is not possible except in horses that have undergone previous sinus surgery. Direct examination of the frontal and maxillary sinuses can be achieved via a standard 4 mm arthroscope inserted through a trephine hole in the frontal sinus or with a flexible endoscope (Ruggles *et al*. 1991, 1993; Worster and Hackett 1999). Direct examination enables identification and treatment of some lesions (Ruggles *et al*. 1993). This procedure is indicated for cases in which disease is identified in the sinus and in which radiographs are inconclusive. Sinus endoscopy is unlikely to be rewarding if radiographs demonstrate complete filling of the sinus with fluid. In these cases, endoscopy results in immersion of the arthroscope in the fluid and yields no information beyond confirmation of the radiographic interpretation of fluid filling of the sinus. In this instance, aspiration and lavage may allow a better examination of the sinus. Endoscopy can be very useful to identify small ethmoid haematomas within the sinus that are not visible radiographically (**Fig 15**). Endoscopy may be able to detect subtle changes in the dental apices or sinus mycosis. Endoscopy can also be used to perform biopsies under direct observation.

Conclusion

Disease of the paranasal sinuses presents a challenge to clinicians. The practitioner may avoid unnecessary delays in instituting appropriate treatments and avoid unnecessary therapies by achieving an accurate diagnosis. The patient's case details and a detailed history may be strongly suggestive of the diagnosis; however, combining the findings of a physical and oral examination, endoscopic examination and high quality radiographs will yield a diagnosis in the majority of cases. Ancillary diagnostic procedures that the practitioner may perform in a practice setting will occasionally be required to achieve a diagnosis.

Manufacturer's address

[1]Allegiance Health care Corporation, McGaw Perk, Illinois, USA.

References

Bell, B.T., Baker, G.J. and Foreman, J.H. (1993) Progressive ethmoid haematoma: background, clinical signs, and diagnosis. *Comp. cont. Educ. pract. Vet.* **15**, 1101-1110.

Cannon, J.H., Grant, B.D. and Sande, R.D. (1976) Diagnosis and surgical treatment of cyst-like lesions of the equine paranasal sinuses. *J. Am. vet med Ass.* **169**, 610-613.

Cook, W.R. and Littlewort, M.L.G. (1974) Progressive haematoma of the ethmoid region in the horse. *Equine vet. J.* **6**, 101-108.

Dixon, P. and Head, K. (1999) Equine nasal and paranasal sinus tumors. Part 2: a contribution of 28 case reports. *Vet. J.* **157**, 279-294.

Gibbs, C. and Lane, J. (1987) Radiographic examination of the facial, nasal, and paranasal regions of the horse: II. Radiological findings. *Equine vet. J.* **19**, 474-482.

Lane, J. (1993) The management of sinus disorders of horses - Part 2. *Equine vet. Educ.* **5**, 69-73.

Lane, J., Longstaffe, J. and Gibbs, C. (1987a) Equine paranasal sinus cysts: A report of 15 cases. *Equine vet. J.* **19**, 537-544.

Lane, J., Gibbs, C., Meynink, S. and Steele, F. (1987b) Radiographic examination of the facial, nasal, and paranasal regions of the horse: I. Indications and procedures in 235 cases. *Equine vet. J.* **19**, 466-473.

Park, R.D. (1993) Radiographic examination of the equine head *Vet. Clin. N. Am.: Equine Pract.* **9**, 49-74.

Ruggles, A.J., Ross, M.W. and Freeman, D.E. (1991) Endoscopic examination of normal paranasal sinuses in horses. *Vet. Surg.* **20**, 418-423.

Ruggles, A.J., Ross, M.W. and Freeman, D.E. (1993) Endoscopic examination and treatment of paranasal sinus disease in 16 horses *Vet. Surg.* **22**, 508-514.

Schumacher, J. and Honnas, C.M. (1993) Dental surgery. *Vet. Clin. N. Am.: Equine Pract.* **9**, 13-152.

Schumacher, J., Honnas, C.M. and Smith, B. (1987) Paranasal sinusitis complicated by inspissated pus in the ventral conchal sinus. *Vet. Surg.* **16**, 373-377.

Trotter, G.W. (1993) Paranasal sinuses. *Vet. Clin. N. Am.: Equine Pract.* **9**, 153-169.

Worster, A.A. and Hackett, R.P. (1999) Equine sinus endoscopy using a flexible endoscope: Diagnosis and treatment of sinus disease in the standing sedated horse. *Proc. Am. Ass. Equine Practnrs.* **45**, 128-130.