Paranasal Sinus Disease in Horses

R. Wayne Waguespack, DVM, MS, DACVS
Jennifer Taintor, DVM, MS, DACVIM
Auburn University

Abstract: The paranasal sinus system of horses is complex, comprising six pairs of sinuses. Disease processes that can develop in the sinuses include ethmoid hematomas, cysts, neoplasia, and bacterial and fungal infections. Horses that develop paranasal sinus disease vary widely in age. A significant number of clinical conditions involving the paranasal sinuses require a combination of diagnostic tests to determine the specific pathologic process. Because of the anatomic location of the paranasal sinuses and associated chronic conditions that affect many patients, many disease processes involving the paranasal sinuses require surgical correction for a favorable prognosis. Fungal and neoplastic processes of the equine paranasal sinuses have a less favorable prognosis than bacterial and other disease processes.

The paranasal sinuses are susceptible to infections that extend from the nasal cavity or from the alveoli of the caudal upper cheek teeth. The diagnosis and treatment of paranasal sinus disease in horses can be complicated. The large size and complex anatomy of the sinuses can allow a pathologic process to be present for weeks or months before any external signs, such as facial swelling or nasal discharge, are noticed by the owner or veterinarian. This can negatively affect the prognosis for a successful outcome and may make treatment of paranasal sinus disease frustrating for clients and clinicians.

Normal Anatomy
The horse's extensive paranasal sinus system consists of six pairs of sinuses: the frontal and dorsal conchal sinuses (commonly known as the conchofrontal sinus), the ventral conchal sinus, the sphenopalatine sinus, and the rostral and caudal maxillary sinuses (FIGURE 1). The major clinically significant sinuses are the frontal and maxillary sinuses. All the sinuses communicate with the nasal cavity directly (maxillary sinuses) or indirectly (dorsal, middle, and ventral conchal sinuses; frontal sinus; and sphenopalatine sinuses) through the maxillary sinus.¹ The conchae (turbinates) are delicate scrolls of bone that are attached laterally in the nasal passage and contain the conchal sinuses. The paranasal sinuses are lined with respiratory mucous membrane composed largely of pseudostratified columnar ciliated epithelium and goblet cells.² The blood flow to the frontal sinus is provided largely by the ethmoidal artery, and the maxillary sinus is supplied by branches of the sphenopalatine artery. The major blood supply to the ethmoidal area is the arterial ethmoidal rete, which is formed from anastomosis of the internal and external ethmoidal arteries, and a minor source is the caudal nasal branch of the sphenopalatine artery.³

The Frontal Sinus
The frontal sinus occupies most of the skull medial to the ocular orbit. More specifically, the frontal sinus extends from a point midway between the infraorbital foramen and the medial canthus of the eye to a point midway between the caudal margins of the orbit in mature horses. The right and left frontal sinuses are separated along the midline by a complete septum (FIGURE 1). The sinus overlaps both cranial nasal cavities and occupies the closed part of the dorsal concha. The conchofrontal sinus is formed by extensive communication between the rostromedial aspect of the frontal sinus and the dorsal conchal sinus. A portion of the floor of the frontal sinus is molded over the ethmoidal labyrinth; rostrolaterally, there is a large oval communication (frontomaxillary aperture) with the caudal maxillary sinus that normally allows natural drainage from the paranasal sinuses.¹

The Conchal Sinuses
Each conchal sinus is divided into a rostral and caudal compartment by a septum. The caudal compartment of the dorsal concha forms the dorsal conchal sinus. The caudal compartment of the ventral concha forms the ventral con-
chal sinus, which communicates with the rostral maxillary sinus over the infraorbital canal through the conchomaxillary opening. The rostral compartments of the ventral and dorsal conchal sinuses are called recesses. The middle conchal sinus lies within the greater ethmoturbinate and is usually of little concern from a surgical standpoint. The dorsal and ventral conchal sinuses are surgically important.

The Maxillary Sinus

The maxillary sinus is the largest sinus. It is divided into rostral and caudal compartments by an oblique septum. In horses younger than 5 years, the maxillary sinus is largely filled with embedded parts of the third to sixth cheek teeth (fourth premolars [Triadan 108 and 208], first through third molars [Triadan 109–111 and 209–211]). As the reserve crowns of cheek teeth become shorter with age, the maxillary sinus enlarges and its rostral limit approaches the infraorbital foramen. The position of the bony septum that divides the maxillary sinus into rostral and caudal parts varies but is usually directed obliquely across the roots of the fourth and fifth cheek teeth (Triadan 109, 110, 209, and 210) approximately 5 cm from the end of the facial crest. The rostral maxillary sinus opens into the middle nasal meatus through a slit-like passageway to the nasomaxillary opening. Medial to the infraorbital canal, the rostral maxillary sinus communicates with the ventral conchal sinus through the conchomaxillary opening.

The caudal maxillary sinus has a large opening caudally and medially over the infraorbital canal into the sphenopalatine sinus. Dorsally, it communicates with the frontal/conchofrontal sinus through the large frontomaxillary opening (approximately 3 x 4 cm). A slit-like passageway between the rostral edge of the frontomaxillary opening and the conchal bulla leads from the caudal maxillary sinus through the nasomaxillary opening and into the middle nasal meatus. This nasomaxillary opening is shared with the rostral maxillary sinus, which also opens into the middle nasal meatus.

The Sphenopalatine Sinus

Equine sphenoid and palatine sinuses are usually contiguous, forming the sphenopalatine sinus. The sphenoid and palatine sinus compartments communicate under the ethmoidal labyrinth. The sphenopalatine sinus communicates freely with the caudal maxillary sinus over the infraorbital canal. Because the sphenopalatine sinus is near vital structures (e.g., the brain, pituitary gland, optic chiasm, nerves, arteries), disease in this sinus could affect these structures as well.

Primary Sinusitis

Primary bacterial sinusitis usually results from a previous upper respiratory tract infection and can be seen in horses over a wide age range. One study indicates that the highest incidence occurs in horses with an average age of 6 years. Common organisms implicated in primary sinusitis include Streptococcus equi equi and Streptococcus equi zooepi-
Inflammation and swelling in the nasal mucosa caused by a viral or bacterial infection can obstruct the nasomaxillary opening, preventing normal sinus drainage from the rostral and caudal maxillary sinuses and thereby predisposing equine patients to sinusitis or exacerbating it. Primary sinusitis usually involves all the sinus cavities but can be confined to the ventral conchal sinus, which can lead to formation of an abscess that is difficult to detect on radiographs and usually requires surgical exploration and treatment. Horses with Cushing's disease may be predisposed to primary sinusitis. However, in a retrospective study by Tremaine and Dixon, only 4.5% (three of 67) of horses with primary sinusitis were also diagnosed with Cushing’s disease.

**Clinical Signs and Diagnosis**

Primary sinusitis is usually unilateral, although bilateral cases have been reported. Mucopurulent nasal discharge is usually present, but malodor is not usually associated with this exudate, as it often is with secondary sinusitis (FIGURE 2). Stertorous breathing may be evident during work or at rest. Facial swelling is uncommon but, if present, usually suggests chronic disease or other disease processes, such as secondary sinusitis, neoplasia, or sinus cysts. Epiphora may be evident with or without facial distortion. Erosion of the cribriform plate with subsequent purulent meningoencephalitis and neurologic signs is a rare complication of severe and chronic sinusitis.

On endoscopic examination, purulent exudate may be observed draining from the nasomaxillary opening into the nasal cavity.
the middle meatus. On radiographs, opacification of both rostral and caudal maxillary compartments is usually seen. Fluid lines should be evident, and in more severe cases, the contents may appear mineralized (FIGURE 3). If primary sinusitis is confined to the ventral conchal sinus, radiography may demonstrate a soft tissue density dorsal to the third to fifth cheek teeth and within the ventral conchal sinus. However, sinusitis is usually well established on presentation, so radiographic findings are similar to those in FIGURE 3. In one study, concurrent opacification of the frontal sinus was also a common finding and helped differentiate primary from secondary sinusitis. Free fluid was more common with primary than with secondary sinusitis. Sinoscopy and sinocentesis allow fluid collection for culture and determination of antimicrobial sensitivity. Sinoscopy performed after sinus lavage to remove purulent debris from the sinus may provide clinicians with more information to differentiate between primary and secondary sinusitis.

**Treatment**

Treatment of primary sinusitis is directed at sinus irrigation with a large volume of warm, sterile, physiologic saline and appropriate systemic antimicrobial therapy; however, the patient’s response can be poor in chronic cases. Drainage and lavage are accomplished by placing an indwelling catheter percutaneously into the maxillary or frontoconchal sinus or by placing lavage catheters in multiple compartments to facilitate adequate lavage of the paranasal sinuses. Primary paranasal sinusitis usually resolves in 7 to 10 days with a combination of systemic antimicrobial therapy and lavage. Some clinicians recommend exercise as part of treatment to stimulate mucus secretion and aid expulsion of sinus exudate.

Systemic antimicrobial therapy alone often diminishes or temporarily resolves nasal discharge but rarely eliminates infection. Delayed or ineffective treatment can result in progression of primary sinusitis to osteomyelitis and advanced necrosis, leading to significant destruction of soft tissue and bone. Surgical debridement and curettage through a bone flap may be necessary in chronic cases with osteomyelitis and abscessation; however, if the exudate becomes inspissated in the ventral conchal sinus, sinusotomy is warranted (FIGURE 4). This condition should be suspected when primary paranasal sinusitis does not resolve with the use of systemic antimicrobials and lavage. Diagnostic signs potentially indicating ventral conchal sinusitis are radiographic or computed tomographic evidence of a soft tissue density over the roots of the maxillary fourth premolar (Triadan 108 and 208) and the first (Triadan 109 and 209) and second (Triadan 110 and 210) molars as well as narrowing of the nasal passage caused by accumulation of inspissated exudate in the ventral conchal sinus (FIGURE 5). Surgical treatment includes removal of exudate from the ventral conchal sinus and, if necessary, additional drainage via maxillary sinusotomy or trephination of the frontal sinus. The technique of establishing drainage through a surgically created sinonasal opening has recently been questioned because of potential lack of efficacy. The surgical opening could alter mucociliary clearance and diminish endogenous production of nitric oxide, which could be bactericidal. However, in my (R. W. W.) experience, creation of a sinonasal opening may be necessary to resolve some chronic sinusitis cases. Surgical treatment of inspissated exudate in the ventral conchal sinus can be effective with the patient under general anesthesia or standing sedation.

**Secondary Sinusitis**

Secondary sinusitis may be caused by dental disease, facial fractures, granulomatous lesions, or neoplasia. Numerous dental problems can lead to secondary sinus disease; periapical disease involving the first molar (Triadan 109 or 209) or the last premolar (Triadan 108 or 208) is the most common. Sinusitis secondary to dental disease accounts for at least half of all sinusitis cases. Horses younger than 4 years...
are diagnosed with dental disease less often than horses in other age groups.5

Clinical Signs and Diagnosis
Affected equine patients usually have a protracted history of foul-smelling, unilateral nasal discharge that does not respond to antimicrobial therapy. Some patients may also have facial distortion and/or draining tracts associated with the sinus11 (FIGURE 6). Maxillary swelling and sinus tracts are more common with apical infections of the first three cheek teeth (Triadan 106–108 and 206–208), whereas nasal discharge is more common with apical infections of caudal cheek teeth (Triadan 109–111 and 209–211). Difficult mastication is not a consistent sign of dental involvement.

Endoscopic examination findings are usually similar in primary and secondary sinusitis. Although an oral examination should always be attempted, defects observed in the exposed dental crowns are not always associated with periapical disease.11 The oral examination should include examination of the occlusal surface of each tooth for a patent infundibulum, fracture, and malocclusion as well as examination of the gingival margins for gingival retraction and inflammation, which may be the only signs of tooth involvement in some cases. The absence of dental lesions does not rule out an apical infection.12

Signs indicating evidence of dental disease on lateral radiographs include proliferative changes of osteitis characterized by localized and ill-defined areas of increased radiopacity and coarseness of bone texture overlying the affected tooth root.16 The most consistent sign is an area of increased lucency around the affected dental apex or apices. The zone of osteolysis is usually surrounded by sclerotic bone. In many cases, the roots may be partly destroyed or distorted and "clubbed" (cement deposition).16,17 In one study, five radiologists correctly identified the presence or absence of radiographic evidence of dental disease and the tooth or teeth involved in only 20% of cases.11 This underlines the importance of combining all aspects of a case workup to make an accurate diagnosis. Nuclear scintigraphy with 99technetium-methylenediphosphonate may provide a useful adjunctive method for identifying the location of a periapical abscess but has the disadvantages of (1) lacking a good three-dimensional representation of the sinuses and (2) potential false-negative and false-positive results due to artifacts. However, when this method is combined with radiography and, in some instances, sinoscopy, it can be almost 100% accurate.18 Computed tomography (CT) is probably the current gold standard for complete evaluation of the paranasal sinuses in equine patients (FIGURE 5). Major advantages
of CT include no superimposition of structures as seen on radiographs. In addition, fluid densities can be characterized, individual tooth roots can be visualized well, and the condition of the sinus openings can be evaluated. Disadvantages of CT include the need for general anesthesia; however, CT can be performed just before surgery to avoid additional expense and recovery from anesthesia. Magnetic resonance imaging can also be used to evaluate the sinuses, especially when CT is not available.

Treatment
Secondary sinusitis is treated by removing the diseased tooth or other primary problem and abnormal mucosa, irrigating the sinus cavity, and administering systemic antimicrobials. Diseased tooth roots are usually removed via oral extraction, trephination over the appropriate region of the maxillary sinus, or sinusotomy of the frontonasal or maxillary bones. During repulsion, care should be taken to properly seat the punch to avoid trauma to the hard palate and surrounding alveolar bone. Intraoperative radiographs should be obtained to ensure that all of the affected bone and tooth was removed. After the affected tooth is successfully repelled, dental packing is placed to prevent communication between the sinuses and oral cavity. This is necessary to prevent contamination of the sinuses and allow healing of the alveolar bone. Veterinarians have used several materials as dental packing, such as polymethylmethacrylate and plaster of Paris. The sinus mucosa or membrane must also be removed as completely as possible to avoid postoperative drainage. The affected sinus should be thoroughly and frequently lavaged as described for primary sinusitis. Unsuccessful treatment can be attributed to persistent osteitis, abscesses, failure to remove all the involved root and infected bone, and failure to treat for obligate anaerobes.

Ethmoid Hematoma
An ethmoid hematoma is a nonneoplastic, progressive, and locally destructive growth in the paranasal sinuses that resembles a tumor in appearance and development (FIGURE 7). Ethmoid hematomas usually occur unilaterally. The largest and most common hematomas arise from the ethmoidal labyrinth, while smaller and less common lesions originate from the floor and walls of the maxillary sinuses, rarely invading the nasal passages. As the hematoma expands, it causes pressure necrosis of surrounding bone and spreads into the frontal sinus, sphenopalatine sinus, nasal passages, and nasopharynx. Ethmoid hematoma rarely causes facial distortion. Ethmoid hematoma is most commonly seen in horses older than 6 years but was described in one case report involving a foal. The condition seems less common in Standardbreds than other breeds, and bilateral disease is more common in mares, occurring in approximately 31% of cases.

Clinical Signs and Diagnosis
The most predominant clinical sign of ethmoid hematoma is unilateral epistaxis resulting from capsule ulceration as the hematoma expands. The amount of hemorrhage is usually scant, intermittent, and unassociated with exercise. Depending on the size, location, and extent of the lesion, other clinical signs (e.g., coughing, dyspnea, fetid breath, facial deformity over the paranasal sinuses) can occur. Stertorous respiration may be heard at rest but is more pronounced during exercise, and airflow may be reduced in the nostril on the affected side. Endoscopically, an abnormality can be seen in most cases. However, absence of a mass in the nasal passage does not rule out a lesion within the sinuses. Endoscopic findings in early cases can include hemorrhage from the ethmoid meatus or nasomaxillary opening or distortion and discoloration of the great ethmoid turbinate. In advanced cases, the hematoma may become visible in the ethmoid region. The hematoma may expand slowly, obstructing the middle or ventral meatus or both or extending through the choana into the nasopharynx. The surface of the mass is usually smooth and glistening, may be ulcerated, and may be reddish purple or greenish yellow. The hematoma may extend into the frontal sinus or ventrally into the sphenopalatine sinus and may continue to expand.
into the caudal or rostral maxillary sinus. Radiographs are useful in determining the size, location, and extent of sinus involvement. The hematoma appears as a smooth-walled, well-circumscribed density that contrasts well with air in the sinus. Because CT provides a cross-sectional view of the skull, it is useful for determining the exact location and extent of the hematoma involvement (FIGURE 8). A tentative diagnosis can be made from the history, clinical signs, endoscopic appearance, and radiographic findings, but a definitive diagnosis can be made only through histopathologic examination of the involved tissue.

Treatment
If the lesion is not treated, the prognosis is unfavorable because the hematoma usually enlarges, eventually obstructing the nasal passages and leading to dyspnea. Ablation of the intranasal portion of the hematoma with a neodymium:yttrium (Nd:YAG) laser and/or intraslesional injection of 4% formaldehyde solution can be performed as standing procedures through an endoscope. Lesions limited to the ethmoid recess that are less than 5 cm in diameter respond more readily to endoscopic Nd:YAG laser therapy but can also be treated with formaldehyde injection. Intraslesional 4% formaldehyde treatment is inexpensive and usually free of complications. However, most lesions need to be reinjected with formalin repeatedly, with a period of 3 to 4 weeks between treatments. If the hematoma extends into the sinus, intraslesional injection of 4% formaldehyde solution into the sinus component can lead to severe sinusitis, conchal necrosis, and, rarely, destruction of the cribriform plate with subsequent brain damage. Surgical treatment for lesions that fail to respond to endoscopic Nd:YAG laser injections involves removal of the entire lesion through a frontonasal bone flap with or without ablation by an Nd:YAG laser. This procedure is usually performed with the patient under general anesthesia in lateral recumbency. The frontonasal approach allows greater access to the lesion because the hematoma may be enclosed in bone. The origin of the hematoma must be removed, which may be difficult if it lies within the ethmoid labyrinth or sphenopalatine sinuses. Identifying the origin may also be difficult due to significant intraoperative hemorrhage originating from the damaged nasal and sinus mucosae or the ethmoid hematoma. It is not unusual to create a communication between the sinus and nasal passage with complete removal of the hematoma. Before surgery, it is recommended to have the horse cross-matched and have a blood donor immediately available for transfusion in case of substantial hemorrhage. In the literature, the recurrence rate after surgical removal of ethmoid hematomas is estimated to be 0% to 44.4%, and long-term remission of clinical signs is reportedly 33%. Bilateral lesions have a reported recurrence rate of 43% compared with an 8% rate for unilateral hematomas. Repeat endoscopy is recommended every 6 months because recurrence is usually recognized within the first 6 to 12 months following surgery. Recurrence should be based on endoscopic findings, not the presence or absence of clinical signs, because evidence of epistaxis does not always indicate recurrence of the lesion.

Sinus Cyst
Sinus cysts are extensive lesions of unknown etiology that are single or loculated, fluid-filled (yellow acellular fluid) cavities with an epithelial lining (FIGURE 9). They develop in the maxillary sinuses and ventral conchae but can extend into the frontal sinus and nasal cavity. Abnormal development of embryonic germ tissue (developmental dental cysts) and cystic development caused by repeated submucosal hemorrhage (mucoid maxillary sinus cysts) have been proposed as etiologic factors. Histologic examination of excised tissue may help differentiate the two. Most cysts do not have dental involvement. In most reports, histologic findings from excised tissues have been relatively nonspecific and have included granulation tissue, neovascularization, ulceration, and, occasionally, mineralization and bony trabeculation in the cyst wall. In some horses, the cyst appeared to be a part of the sinus lining; in other horses, the sinus appeared to be occupied by a cystic mass that had grown out from the turbinates. A congenital form is a reported cause of facial swelling and dyspnea since birth in foals. Previously, sinus cysts were thought to occur in young horses only, but studies have confirmed the diagnosis of sinus cysts in older horses.
Clinical Signs and Diagnosis
The major clinical signs of a sinus cyst are facial swelling, nasal discharge, sinus dullness on percussion, and airway obstruction. The nasal discharge is usually not hemorrhagic or malodorous. On endoscopic examination, the nasal passage appears narrow and the ventral conchae may appear enlarged, or the cyst may be observed in the nasal passage. Radiographic features are often nonspecific, including diffuse sinus opacification, occasional gas-soft tissue interfaces, thickening of overlying bone, distortion of the tooth roots, deviation of the nasal septum, and mineralized densities within the sinus. Sinocentesis typically results in a large quantity of viscous, clear to amber fluid. Cytologic examination of this fluid is usually unrewarding.

Treatment
Surgical removal of the cyst and involved conchal lining carries a good prognosis for complete recovery. Irrigation of the sinus after surgery removes debris and blood clots from the sinus, accelerating postoperative recovery. The sinuses are frequently so disrupted by the cyst that a large communication is established into the nasal passages after surgery, resulting in recurrent, but clinically insignificant, mucous discharge in some patients. The recurrence rate is low with surgical excision.

Wounds and Fractures
Blunt injuries to the frontal sinus and nasal bones caused by kicks from other horses or collisions with fixed objects can cause open or closed wounds to the sinuses (FIGURE 10). Many wounds go unnoticed because the fracture fragments may be forced into the sinus cavity and either the skin detaches from the bone or the integrity of the skin is not disrupted. As healing occurs, the fracture callus produces a firm subcutaneous swelling along the fracture line, or if there is a depression fracture, a facial concavity is present.

Clinical Signs and Diagnosis
Epistaxis and subcutaneous emphysema are common clinical signs of sinus trauma, but dyspnea and epiphora are also possible. In acute cases, it may be possible to feel a hematoma and fracture fragments. Severe trauma to the head and sinuses can cause ocular and central neurologic signs. The configuration of the fracture is often defined more readily by physical examination rather than radiography; however, radiographic examination of fractures is indicated to detect additional fractures and determine whether there is involvement of the rostral or dorsal aspect of the cranial vault. Fracture fragments and fluid lines from blood
within affected sinuses can be seen on standard radiographic views, but oblique views may be necessary to demonstrate injury. Patients with fractures near the cranial vault should be thoroughly evaluated and monitored for the presence or development of neurologic signs such as blindness, mental depression, ataxia, or vestibular dysfunction. Depression fractures involving the orbit cause the globe to collapse into the sinuses and the third eyelid to prolapse.

**Treatment**

Mild, stable depression fractures can be left untreated if cosmesis is not important. Unstable fractures, markedly depressed facial fractures, and fractures of the zygomatic arch should be treated surgically for ocular health. Surgical correction is performed with the patient under general anesthesia and usually not for at least 24 hours after injury due to possible complications secondary to cranial trauma.

General goals for surgical repair of facial fractures include reconstruction of facial contours and reduction of potential sequestrum and sinusitis formation by incorporating or discarding bony fragments devoid of a blood supply. Surgical reduction of simple depression fractures should initially be attempted through stab incisions to minimize disruption of surrounding soft tissue structures that provide stability and blood flow to the fracture. Successful surgical reconstruction of more extensive facial fractures may require complete field exposure via a generous skin incision. Depressed fragments should be elevated and free fragments collected. Fragments can be connected using monofilament absorbable suture or stainless-steel suture. A Steinmann pin or small drill bit can be used to create holes for suture placement. Secure apposition of subcutaneous tissue and skin adds stability and provides access to a blood supply. When fractures near the medial canthus are reconstructed, a special attempt should be made to salvage the nasolacrimal canal. Surgical creation of communication between the proximal part of the nasolacrimal duct and the maxillary sinus has been successful when salvage is not possible. Equine patients should recover from anesthesia with the surgical site bandaged and, when possible, with a padded head guard.

Extensive fractures that invade the sinus or nasal cavity should be treated with systemic antimicrobials before surgery and for 10 to 14 days after surgery. Open defects secondary to the initial traumatic event can result from skin or bone loss involving the sinus or nasal cavity. Delayed repair of sinus defects using muscle flaps or periosteal flaps has also been described.

**Sinus Neoplasia**

Neoplasia of the paranasal sinuses is rare in horses. Although several reports of individual cases have been reported in the literature, the incidence of sinus neoplasia is approximately less than 1% of sinus diseases. In older horses, reported tumor types include squamous cell carcinoma (SCC; the most common), adenocarcinoma, fibrosarcoma, osteoma, osteosarcoma, myxoma, myxosarcoma, and unspecified carcinomas; in young horses (younger than 2 years), fibrosarcoma, osteoma, and osteosarcoma are typically reported.

Although tumors can develop at a variety of sites within the paranasal sinuses, certain tumor types have a predilection for development at specific locations, most likely as a result of the histologic differences of mucousae. SCCs and bony tumors are frequently encountered in the maxillary sinus, while adenocarcinomas appear more commonly in the frontal sinus. While these tumors are locally aggressive, expanding into surrounding tissue, metastasis is rare.

**Clinical Signs and Diagnosis**

The most common clinical signs of neoplasia include unilateral mucopurulent or purulent nasal discharge, facial swelling, and reduced nasal airflow. Additional reported clinical signs include epistaxis, bilateral nasal discharge, dyspnea, ocular discharge, epiphora, head shaking, localized lymph node involvement, and neurologic deficits.

Because of the tortuous ostia between the nasal cavity and paranasal sinus, nasal endoscopic examination of the paranasal sinuses is not possible. The paranasal sinuses can be directly examined by sinoscopy; however, mucopurulent material or the tumor may prevent adequate visualization. Radiography combined with CT of the sinuses provides the most definitive information regarding the location of the mass and the extent of involvement of surrounding tissues. Definitive diagnosis was made by histopathologic examination of a biopsy specimen of the mass.
between neoplasia and sinonasal masses.\(^{5,47,49}\) (FIGURE 11).

Definitive diagnosis can be made by histopathologic examination of a biopsy specimen of the mass, preferably from deep within the tumor because a superficial sample may show only inflammatory cells or necrotic debris.\(^{6,45–49,58,60}\)

**Treatment and Prognosis**

Surgical treatment is typically unrewarding due to the extent of local destruction at the time of diagnosis and the propensity for recurrence, especially with carcinomas.\(^{45,47,49,60,61}\) However, osteomas respond well to surgical removal because they are benign and usually form well-circumscribed lesions with pedunculated or sessile attachments.\(^{46,47,49,55,57,60,61}\) Use of external beam radiation therapy as a primary treatment (only for SCCs) and an adjunct to surgical removal (only for fibromas) has reportedly been somewhat successful in treating paranasal neoplasia in equine patients.\(^{47,62,63}\) For other types of neoplasia, there are not enough data regarding the efficacy of external beam radiation therapy.

**Fungal Infections**

Fungal infections of the paranasal sinuses are rare. Saprophytes (e.g., *Cryptococcus neoformans*, *Coccidioides immitis*, *Allescheria boydii*, *Pseudallescheria boydii*), commonly found in manure and soil, are typically reported. These organisms have been isolated from granulomas in the frontal, maxillary, sphenopalatine, and conchal sinuses.\(^{6,47,49,64–66}\) These granulomas can cause progressive bone destruction, resulting in involvement of localized structures, such as the eyes and brain. Although fungal infection has been reported to disseminate to other organs, such as the lungs and jejunum, it is extremely rare.\(^{57}\) Localized or diffuse sinusitis caused by *Aspergillus* and *Penicillium* spp has also been reported.\(^{57}\) When dealing with horses with cryptococcosis, veterinarians and owners need to remember the zoonotic potential of *Cryptococcus* spp.\(^{38}\)

**Clinical Signs and Diagnosis**

Clinical signs of fungal infection are similar to those of neoplasia and sinusitis: unilateral nasal discharge, facial deformity, and obstructed airflow. Depending on the size of the granuloma and involvement of localized tissues, blindness, exophthalmos, and swelling of the periorbital region may be observed.

Radiographic examination of the sinuses may show a soft tissue density of the affected sinus, while endoscopic examination of the sinuses may show a lobulated or non-lobulated mass extending from the paranasal sinus into the nasal cavity. Aspiration or biopsy of the mass is needed to make a definitive diagnosis.

**Treatment**

Treatment of fungal infection consists of surgical removal or debulking and/or antifungal therapy. Topical application of amphotericin B, miconazole, and natamycin; local injection of amphotericin B; and/or systemic administration of iodides, amphotericin B, and ketoconazole have been used with variable effects in treating sinus granulomas.\(^{45,47,61,64}\) A horse with *P. boydii* sinusitis had a successful outcome after topical application of miconazole and systemic administration of sodium iodide.\(^{64}\) Topical application of enilconazole or natamycin has had favorable results in treating *Aspergillus* spp sinusitis.\(^{47,67}\) However, the prognosis for successful treatment of fungal infections of the paranasal sinuses tends to be guarded or unfavorable.

**Conclusion**

Paranasal sinus disease can be diagnosed and treated successfully with the appropriate combination of medical and surgical therapy. However, paranasal sinus disease in horses can be complicated. The large size and complex anatomy of the sinuses can allow a pathologic process to be present for weeks or months before external signs, such as facial swelling or nasal discharge, are noticed by the owner or veterinarian. This can negatively affect the prognosis for a successful outcome and may make treatment of paranasal sinus disease frustrating for clients and veterinarians.

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1. Which teeth are associated with the maxillary sinuses?
   a. only the first through fourth cheek teeth
   b. only the fifth and sixth cheek teeth
   c. only the fourth premolar and the first through third molars
   d. only the first through fourth molars

c. inspissated exudate in the maxillary sinus
d. none of the above (Primary sinusitis always resolves with time.)

5. The most common cause of secondary sinusitis is
   a. dental disease.
   b. neoplasia.
   c. facial fracture.
   d. primary sinusitis.

6. The most consistent radiographic sign of secondary sinusitis due to dental disease is
   a. a fluid line in the sinuses.
   b. an area of increased lucency around the affected tooth apex.
   c. a soft tissue opacity associated with the affected sinus.
   d. osteitis.

7. The most predominant clinical sign of ethmoid hematoma is
   a. exercise intolerance.
   b. stridor.
   c. unilateral epistaxis.
   d. bilateral epistaxis.

8. Etiologic factors associated with sinus cysts include
   a. dental disease.
   b. abnormal development of embryonic tissue.
   c. trauma.
   d. chronic primary sinusitis.

9. The most common neoplasia of the sinuses is
   a. lymphosarcoma.
   b. SCC.
   c. fibrosarcoma.
   d. osteomas.

10. A __________ sp has been associated with fungal granulomas of the sinuses.
    a. Conidiobolus
    b. Pythium
    c. Cryptococcus
    d. Aspergillus