

## **Diagnosis and treatment of a paranasal sinus cyst in an 18 month old**

**Thoroughbred colt:**

**ID NUMBER:**

### **INTRODUCTION:**

This case report describes a yearling Thoroughbred colt that was diagnosed with a paranasal sinus cyst located in the left caudal maxillary sinus. The colt presented with a unilateral mucopurulent nasal discharge, facial deformity and stertorous breathing. A diagnosis was achieved through a combination of clinical findings, endoscopy, radiology, centesis and histopathology. Resolution of the clinical signs was achieved through surgical removal of the cyst. This case demonstrates the challenges faced in diagnosis and treatment of a paranasal sinus cyst in a horse.

The occurrence of sinonasal disease has been widely reported in the literature. The prevalence of the disease is, however, surprisingly low, with an 1.06% of the general population being affected.<sup>1</sup> Additionally, an equine practice survey identified only 75 cases of sinonasal disease in a total of 17,000 horses presented for veterinary examination.<sup>2</sup>

Cases of sinonasal disease typically are chronic in nature and often present difficulties in diagnosis and treatment. For this reason it is typical for the horse to be presented in an advanced state of disease. It has been proposed that the median wait time before veterinary consultation for a horse with clinical signs suggestive of sinus disease is 12 weeks from the onset of clinical signs.<sup>2</sup> In addition to delayed veterinary intervention, the complex anatomy of the paranasal sinuses, the difficulty accessing them, and the

fact that most sinus diseases present with very similar clinical signs, further compounds the challenge of diagnosis and treatment.

Despite the reportedly low prevalence of sinonasal disease in the general population, paranasal sinus cysts are reported to be common amongst horses with sinonasal disease.<sup>3</sup> Sinus cysts have been reported to be the third most common cause of sinonasal disease after primary and secondary sinusitis.<sup>2,3</sup>

Sinus cysts are epithelium lined, fluid filled cavities that occur in the paranasal sinuses of horses. They develop in the maxillary sinuses and ventral concha and can expand into the frontal sinus.<sup>4</sup> Sinonasal cysts are usually solitary, but there are reports of multilocular cysts.<sup>4,5</sup> Unilateral paranasal sinus cysts are most common, but cases of bilateral cysts have been reported.<sup>6</sup>

There does not seem to be any sex or breed predilection.<sup>4</sup> A biphasic age distribution for the occurrence of sinonasal cysts has been reported, with peaks at <1 and > 9 years of age<sup>4</sup>. It has been documented, however, that paranasal sinus cysts can be found in any age of horse.<sup>2,3</sup> Clinical signs can be largely attributed to the expansile nature of the lesion. The most common clinical findings include unilateral nasal discharge, facial distortion and dyspnea.<sup>2</sup> In this regard, a horse with a paranasal sinus cyst may present with signs similar to cases with other expansive disorders such as progressive ethmoid hematoma and neoplasia.<sup>3</sup>

To fully understand the etiology and pathophysiology, the challenges to diagnosis and treatment of equine paranasal sinus disease and, more specifically paranasal sinus cysts, a thorough knowledge of equine sinus anatomy is required.

There are six paranasal sinuses in the horse which are interrelated: the frontal, dorsal conchal, ventral conchal, rostral maxillary, caudal maxillary and sphenopalatine (Figure 1). They communicate directly or indirectly with the nasal passages via the nasomaxillary apertures.<sup>7</sup>

The conchal sinuses communicate with the frontal (dorsal conchal) and maxillary sinuses (middle and ventral conchal sinuses). The conchae are scrolls of thin bone that divide the nasal passages into dorsal, middle, ventral and common nasal meati.<sup>8</sup> Most clinically important diseases involve the frontal and maxillary sinuses.<sup>9</sup>

The sinuses are lined by a pseudostratified ciliated columnar respiratory epithelium, which is interspersed with goblet cells and underlying serous glands.<sup>10</sup>

The frontal sinus is dorsal and medial to the orbit. The left and right frontal sinuses are separated by a median septum. An extensive communication exists between the rostromedial aspect of the frontal sinus and the dorsal conchal sinus; together they are referred to as the conchofrontal sinus.<sup>7</sup>

The maxillary sinuses are paired and are both rostral and caudal to the orbit. The rostral and caudal maxillary sinuses share a common slit like communication, which directs drainage through the nasomaxillary opening into the middle nasal meatus of the nasal cavity. The dorsal location of this opening precludes gravitational drainage from the ventral recesses of the maxillary sinuses. Apart from this communication these sinuses are completely divided into rostral and caudal compartments by a bony septum.<sup>8</sup> The position of the septum is variable, but is usually directed obliquely across the roots of the 4th and 5th cheek teeth (Triadan,109,110 and 209,210).<sup>5</sup> In horses under five years of age the maxillary sinuses are largely filled with embedded reserve crowns of the 3rd

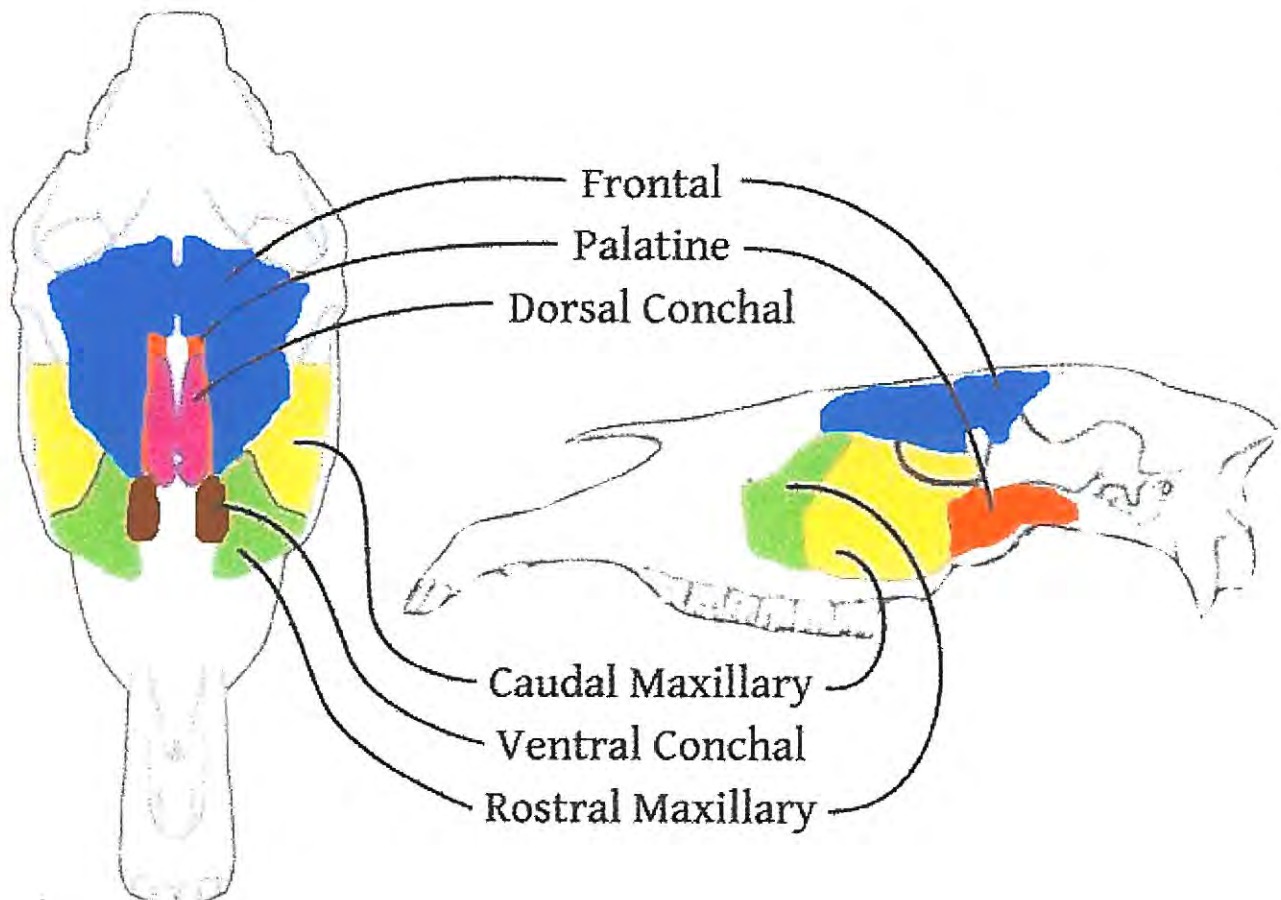


Figure 1: Illustration of the 6 paired paranasal sinuses in the equine skull, depicting the anatomical boundaries of each sinus and the close approximation of the sinuses to one another.

to 6th cheek teeth; (Triadan,108-111,208-211). As the reserve crowns migrate orally with age, the maxillary sinus enlarges and its rostral limit approaches the infraorbital foramen.<sup>5</sup> The ventral part of the rostral and caudal maxillary sinuses is also divided into medial and lateral spaces by an upright longitudinal plate supporting the infraorbital canal. The medial aspect of the caudal maxillary sinus communicates with the sphenopalatine sinus, and allows drainage from this sinus into the caudomaxillary sinus. The medial part of the rostral maxillary sinus extends into the ventral concha<sup>8</sup> through the conchomaxillary opening, which is located dorsal to the infraorbital canal. The caudal maxillary sinus also opens medially into the middle conchal sinus, in addition to communicating with the frontal sinus dorsally via the frontomaxillary opening. This opening normally allows easy natural drainage, from frontal to caudal maxillary sinus.<sup>8</sup> The conchofrontal sinuses have no direct communication with the nasal cavity and, therefore, have to drain into the caudal maxillary sinus. This feature is unique to horses, amongst domestic species.<sup>8</sup>

Blood flow to the frontal sinus is provided mainly by the ethmoid artery, and the maxillary sinus is supplied by branches of the sphenopalatine artery.<sup>5</sup>

A sound understanding of the anatomy and, in particular, the drainage patterns of the paranasal sinuses permits a better understanding of the disease processes that originate within this complex labyrinth.

The exact etiology of paranasal sinus cysts is unknown.<sup>1,3,10,11</sup> There are conflicting reports in the literature.<sup>2,3,10</sup> A knowledge of the histological features observed is, therefore, necessary to ascertain the validity of each proposed etiology. There appears to be a consensus regarding the histological appearance of a typical paranasal sinus

cyst.<sup>4,10,12</sup> Paranasal sinus cysts are expansile, mucus filled cavities, capable of bone destruction. They possess a mucus secreting epithelial lining, which is typically accompanied by a local mild inflammatory process.<sup>2,11</sup> Paranasal sinus cyst contents have been identified as lymphocytes, macrophages and erythrocytes in one case<sup>13</sup> and as predominately neutrophils in five other cases,<sup>10</sup> suggesting an inflammatory process within the cyst. This low grade inflammatory response is a consistent feature of the paranasal cyst, compared with a sinusitis which typically demonstrates a more intense inflammatory response.<sup>10</sup> It is typical for respiratory epithelium to be present on both sides of the cyst capsule, although the presence of ciliated columnar epithelium on only the luminal surface of a cyst is evidence enough to distinguish the lesion from maxillary or mandibular epidermoid cysts, and from abscesses.<sup>4,10,14</sup>

Sub-epithelial hemorrhage and infiltration of the cyst wall with hemo-siderophages is also typical for paranasal sinus cysts: the hemorrhage ranges from the presence of hemosiderin laden macrophages to extravasated blood.<sup>4</sup> However, hemorrhage has been reported as an inconsistent finding.<sup>10</sup>

A consistent finding, however, in cases where bone remodeling is found is the presence of spicules of bone in the cyst lining. These spicules demonstrate varying degrees of remodeling as evidenced by osteoblastic and osteoclastic activity.<sup>10</sup> It is the release of prostaglandin E2 by the osteoclasts that is responsible for bone resorption, which may facilitate cyst expansion.<sup>15</sup>

Human mucocoeles appear to be histologically very similar to equine paranasal sinus cysts.<sup>16</sup> The contents of both human mucocoeles and equine sinus cysts appear to be bacteriologically sterile,<sup>4,10,12,13,17</sup> although secondary bacterial infection has been

reported.<sup>6,12</sup> The wide range of histologic features identified has resulted in the proposed multiple etiological theories. Because the definitive etiology of paranasal sinus cysts is unknown, numerous contradictory theories have been suggested over the years. The etiology of paranasal sinus cysts can, however, be broadly characterized as either congenital<sup>11</sup> or developmental.<sup>18</sup>

In cases of congenital sinus cysts, an odontogenic etiology has been reported, with a possible association with dentigerous tissues.<sup>19,20</sup> Several authors believe paranasal sinus cysts are attributable to tooth root abnormalities.<sup>1,21</sup> Due to the close association between the maxillary sinus and the embedded parts of the third to sixth cheek teeth (Triadan, 108-111, 208-211), it is not unrealistic to suggest that maxillary cysts are caused by dental cysts, which develop within and distend the maxillary sinuses.<sup>22</sup> It has been proposed, for example, that hemorrhage in a developing tooth root may lead to a cystic cavity which persists in the sinus following hemolysis.<sup>23</sup> Moreover, cysts lined with epithelium of dental origin within the maxillary sinuses have been recognized.<sup>24</sup> Radiographic flattening of the tooth roots in horses diagnosed with sinus nasal cysts has been cited as further evidence to support a dental origin.<sup>4</sup> It has been suggested, however, that this dental distortion is more likely the result of pressure from the sinus nasal cyst than from a primary tooth abnormality.<sup>3,10,25</sup>

Cellular elements of dental origin must be present in tissues to confirm a diagnosis of developmental dental disease.<sup>23</sup> There are, however, multiple case studies in which sinus cysts cannot be histologically related to a dental origin.<sup>3,10</sup>

Congenital paranasal sinus cysts, of non-dentigerous origin, have also been reported.<sup>5,13</sup>

Historical literature has cited a congenital blockage of the nasomaxillary opening as the inciting cause for sinus cyst development.<sup>12</sup>

The fact that sinus cysts are often found in older horses has raised doubt regarding a congenital origin.<sup>10</sup> It has been suggested, nonetheless, that a slow growing congenital cyst could enlarge over time (months to years) before inducing clinical signs, thereby escaping detection until the horse is older.<sup>26</sup>

The remainder of the suggested etiologies consider developmental as opposed to congenital factors.

One theory for the etiology of sinus cysts in older horses is that they are the result of repeated submucosal hemorrhage, the origin of which is unknown.<sup>4,13</sup> In this respect, it is proposed they could share a common etiopathogenesis with progressive ethmoid hematomas.<sup>4</sup> There have been reports of horses concurrently afflicted with sinonasal cysts and progressive ethmoid hematomas.<sup>3</sup> This suggested association with progressive ethmoid hematomas is supported by histological evidence that both lesions contain recent and older hemorrhage.<sup>4</sup> Evidence presented by Tremaine et al(1999), however, showed that the presence of recent and old hemorrhage was not exclusive to these two lesions and that this finding occurred in several cases of chronic sinusitis.<sup>10</sup> Additionally, the double respiratory epithelial lining characteristic of sinus cysts, was not found in any of the progressive ethmoid hematoma cases in the aforementioned study. Further, none of the progressive ethmoid hematoma sections in this study contained bony spicules, another characteristic histological finding of sinus cysts.<sup>2,10</sup> Important fundamental differences, which contradict a similar etiopathogenesis are that sinus cyst's are fluid filled while progressive ethmoid hematoma's are solid<sup>25</sup> and that



paranasal sinus cysts have a good prognosis for resolution of clinical signs, whereas recurrence is common with cases of progressive ethmoid hematomas.<sup>5</sup>

Paranasal cyst development, subsequent to an acquired blockage of the nasomaxillary opening, has been proposed as another etiology for developmental cysts. In one case, a blockage was reported to be caused by a maxillary osteoma.<sup>2,12</sup> The development of mucocoeles in humans, which are histologically very similar to paranasal sinus cysts in horses has also been attributed to an obstruction of the sinus ostium.<sup>17</sup> Causes of such obstructions may be due to persistent inflammation, trauma, infection or previous surgery.<sup>15</sup>

One historical etiological theory, suggested in 1968, was that of facial osteodystrophy caused by a secondary nutritional hyperparathyroidism associated with excess grain feeding.<sup>12,18</sup> It was hypothesized that multiple cysts developed within the degenerated maxillary bones. This theory has received little recognition in recent years, as it is not supported by histological findings.

Considering the complex nature of the paranasal sinus system and the number of different tissue types in this area: epithelial, dental and bone, it is not surprising that there are a wide array of etiological theories. It may be that not all cysts share a common etiology and that a cyst may be the endpoint of several distinct etiological processes.<sup>27</sup>

The typical history of horses with a paranasal sinus cyst can vary widely, depending on: the cyst location, the structures involved, and the length of time the cyst has been present. Clinical signs arise when the fluid-filled sinus overflows into the turbinates,

when pressure accumulates in the sinuses and produces physical changes, or when the sinus becomes secondarily infected.<sup>11</sup>

Typical clinical signs of paranasal sinus cysts include, but are not limited to: nasal discharge, facial distortion, dyspnea, epiphora, facial drainage tracts and submandibular lymphadenopathy.<sup>11</sup> In one case, exophthalmia, secondary to a paranasal sinus cyst in the caudal maxillary and conchofrontal sinuses, was reported.<sup>28</sup> One horse in a study by Woodford and Lane (2006) demonstrated vertical head shaking as a dominant clinical feature.<sup>3</sup>

The three most consistent clinical signs: nasal discharge, facial distortion and airflow obstruction,<sup>10</sup> are discussed in more detail below.

Nasal discharge is usually unilateral. In one reported group, of 37 horses diagnosed with sinus cysts, 92% had a unilateral nasal discharge.<sup>2</sup>

In those horses with unilateral lesions but bilateral discharge, the discharge was attributed to either a gross nasal obstruction, causing discharges to pool in the pharynx before flowing down the contralateral as well as the ipsilateral nasal cavity,<sup>2</sup> or due to a secondary sinusitis caused by the physical obstruction to the normal sinonasal drainage.<sup>2,10,29</sup>

The nature of the discharge is variable, most commonly being mucopurulent or purulent, and less frequently sanguinous. Discharge is thought to be the result of sinus infection secondary to obstruction of normal sinonasal drainage.<sup>2,30</sup> Facial swelling is a consistent clinical feature caused by the expansile nature of sinus cysts leading to distortion of the frontal, maxillary and conchal bones.<sup>4,31</sup> Tremaine, et al. (2000) reported 77% of horses diagnosed with sinus cysts had some form of facial distortion.<sup>2</sup>

The distortion of bone has two mechanisms: pressure atrophy of the bone, leading to maxillary or frontonasal swellings,<sup>3</sup> and osteoblastic/osteoclastic activity from the cyst, mediated by the production of prostaglandin E2 by the osteoclasts, which leads to direct bone remodeling.<sup>10</sup>

Nasal airflow obstruction completes the triad of common clinical signs of paranasal sinus cysts. Obstruction arises when the nasal meati are compressed or obliterated through cyst expansion, when there is impingement of the medial walls of the conchae into the nasal passage, and/or when there is displacement of the nasal septum by the cyst.<sup>2</sup> Tremaine et al. (2000) reported that 48% of horses with cysts suffered from nasal airflow obstruction.<sup>2</sup>

These three cardinal signs of a paranasal sinus cyst are, however, fairly non specific and can be found in horses with other paranasal sinus diseases, besides paranasal sinus cysts. It is apparent, therefore, that the clinical signs alone are not pathognomonic for a paranasal sinus cyst.<sup>1,4</sup> The low specificity of clinical signs, therefore, makes the physical exam, and subsequent diagnostic aids, vitally important in this challenging diagnostic process.

The list of differential diagnoses for paranasal sinus cysts includes but is not limited to: primary sinusitis; dental sinusitis; sinonasal neoplasia; progressive ethmoid hematoma; trauma; foreign bodies; mycosis as well as periapical infections of teeth located within the sinus and sinonasal polyps.<sup>2,3,4,32</sup> Some of the less common differentials include congenital malformation of the maxilla<sup>33</sup> and *Halicephalobus gingivalis* infection (a saprophytic nematode found in decaying humus, which causes an infection of the sinuses through an unknown route).<sup>34</sup> A sinus cyst should also be considered in any

horse demonstrating neurologic signs along with the more typical signs of sinus disease, due to the possibility of destruction of the cribriform plate with subsequent meningoencephalitis which can be an extremely rare complication of any chronic sinus disease.<sup>5</sup> Finally, lower respiratory tract infections should always be considered if nasal discharge and difficulty breathing are the presenting clinical signs.<sup>35</sup>

It is useful to consider the frequency of clinical signs for each of the various diseases listed above, when formulating a differential list.

Although the list of clinical signs is very similar for all sinonasal diseases, the occurrence of specific clinical signs differs between the different disease processes. The appearance of facial distortion, for example, has been reported with decreasing frequency from cases of sinonasal trauma (88%), to sinonasal neoplasia (81%), followed by sinus cysts (77%).<sup>2</sup>

Facial drainage tracts were not a common finding in any sinonasal disease but were most common in cases of sinonasal trauma (12.5%).<sup>2</sup>

Epiphora was found most commonly in cases of sinonasal trauma (53%), with sinus cysts exhibiting epiphora in 42% of cases. Epiphora develops due to compression of the osseous nasolacrimal duct.<sup>2</sup>

Nasal discharge, as reported previously, was a frequent finding in all sinonasal disease processes. A malodorous discharge was most commonly found in horses with sinonasal polyps(100%), dental sinusitis(77%) and cheek teeth infections (73%).<sup>2</sup>

100% of horses diagnosed with progressive ethmoid hematomas were found to have a sanguinous discharge.<sup>2</sup>

Nasal airflow obstruction was most commonly reported in cases of neoplasia (55%) and sinonasal cysts (48%). Stertorous breathing is usually caused by impingement of the medial walls of the conchae into the nasal passage, and sometimes displacement of the nasal septum caused by cyst expansion.<sup>2</sup>

The history of clinical signs, therefore, can be vitally important in helping to refine the differential diagnosis list. For example, knowledge of a prior response to antibiotic therapy is important. Any disease that results in obstruction of the nasomaxillary opening, such as a sinus cyst, can lead to a secondary bacterial infection which may temporarily respond to antibiotics.<sup>36</sup> This is a characteristic anamnesis for a sinus cyst case. The character of any respiratory noise heard is important. A noise resulting from a fixed airway obstruction should be the same during inspiration and expiration and can aid the clinician when formulating a differential list.<sup>36</sup>

Patient age and breed can be suggestive of a certain disease: epithelial neoplasia occurs most commonly in aged horses and, as previously described, paranasal sinus cysts have a biphasic age presentation, typically in horses less than two years old or in those ten to fourteen years of age.<sup>4,11</sup> Breed may also be important in the differential diagnosis: ethmoid hematomas seem to be more common in Thoroughbreds and have not been reported at all in Standardbreds.<sup>37</sup>

Physical examination is of importance when structuring a list of possible differentials. Following a general physical examination, which should aid in ruling out a lower respiratory tract infection, the paranasal sinuses should be percussed to detect space occupying material.<sup>5</sup> Dullness on percussion may indicate the presence of excessive fluid or a tissue mass in the sinus. This technique is not always reliable<sup>5</sup> and an oral

examination should also be performed routinely. The patient is sedated, the mouth is rinsed and an oral speculum is placed. Examination of the oral cavity is considered essential for differentiating between diseases of the sinuses.<sup>38</sup> During the examination, the examiner observes for loose, broken or missing teeth, suggestive of sinusitis secondary to dental disease. Teeth should be examined for abnormal wear and the gingiva around the teeth should be inspected, as separation is suggestive of dental disease. The examiner should identify if single or multiple teeth are involved or if draining tracts or erosive lesions on the mucosa are present. Multiple tooth involvement is common with neoplastic disease.<sup>36</sup>

Particular attention should be paid to the caudal four cheek teeth in the upper arcade, as these teeth have their apices in the maxillary sinuses. Dental disease is a common cause of secondary sinusitis<sup>39</sup> and, therefore, must be ruled out as a differential diagnosis.

Complete blood counts are typically within normal ranges in cases of sinus disease.

There can occasionally be a decrease in the packed cell volume, due to an anaemia of chronic disease.<sup>5</sup>

Subsequent to obtaining the history and performing a thorough physical exam, upper airway endoscopy should be performed.<sup>11</sup> The purpose of the endoscopic exam is two fold: first, to confirm the sinus as the source of the nasal discharge and, second, to detect sinus abnormalities that extend into the nasal passages.<sup>5</sup> Identification of the nasomaxillary opening as the source of the nasal discharge is sufficient evidence to establish the sinus as the origin. However, not all cases demonstrate this discharge.<sup>5</sup> In one study, 72% of horses diagnosed with sinonasal cysts demonstrated a draining

exudate from the caudal aspect of the caudal maxillary sinus.<sup>2</sup> On endoscopic examination, close attention should be paid to any distortion of the nasomaxillary opening which could be due to an expansile mass. Narrowing of the nasal passages should also be assessed. To allow accurate assessment of this the ventral, middle and dorsal nasal meati should each be examined separately.<sup>36</sup> One author reported that out of 52 horses diagnosed with sinonasal cysts 19 had narrowing of the common nasal meatus on the affected side.<sup>3</sup> It should also be noted that a full endoscopic evaluation may be limited due to obstruction of the nasal passages and sometimes endoscopy can be impossible due to nasal passage obstruction caused by cyst expansion.<sup>25</sup> Both nasal passages should be examined for comparison.<sup>5,28</sup> Endoscopy can be diagnostic for some disease processes. For example, the absence of an ethmoid hematoma or guttural pouch disease can often be determined by upper airway endoscopy.<sup>2</sup> Whilst upper airway endoscopy is a useful technique for narrowing the differential list, it is rarely diagnostic for cases of sinonasal cysts. It has been reported that in 37 horses diagnosed with sinonasal cysts, only 10% showed a diagnostically useful lesion on endoscopic examination.<sup>2</sup> This study did show, however, that upper airway endoscopy was most diagnostically useful for progressive ethmoid hematomas and sinonasal mycosis (in 71% and 85% of cases, respectively, a diagnostically useful lesion was found). However, the absence of a lesion extending into the nasal passages on endoscopy does not rule out a mass within the sinuses.<sup>5</sup> Thus a 'normal' upper airway endoscopic examination does not rule out diagnosis of a paranasal sinus cyst.<sup>5</sup> Once endoscopic examination has defined the sinonasal area as the region of interest, radiographs are required to further explore and establish a diagnosis.

Radiographic examination of the horse's skull is notoriously difficult. This is in part due to the symmetric nature of the head, with each structure being superimposed by another of identical shape and size.<sup>40</sup> Radiographic examination should consist of four standard views; a straight lateral, obliques of each side and a dorsoventral view.<sup>41</sup>

These views are easily obtained in the standing horse.<sup>3</sup> The x ray beam is aligned perpendicular to the midline of the head, with the centering points varying depending on clinical indications. For radiography of the frontal and maxillary sinuses, the beam is centered between the orbit and the lateral opening of the infraorbital canal, an inch dorsal to the facial crest.<sup>41</sup> Accuracy of head positioning can be assessed by checking that the premaxillary borders of the nasomaxillary notch are close together and parallel to each other.<sup>42</sup> The lateral view permits visualization of lesions of the frontal and maxillary sinuses and the nasal passages. It is a reliable projection for showing the degree and distribution of any opacification of the paranasal sinuses, for distinguishing between solid and fluid contents and for estimating the quantity of fluid.<sup>41</sup> Soft tissue has an irregular outline whereas fluid forms a gravity-dependent line. This ease of distinction is true, except for a case where the sinus is completely filled by a soft tissue opacity. In such a case, it may be difficult to distinguish between a mass and free fluid. On lateral views, it should be possible to appreciate, where present, increased sinus opacity, thickened sinus walls, mineralization of the paranasal sinus cyst interior, displaced teeth and secondary fluid accumulation in the frontal sinus.<sup>40</sup> Lateral radiographs of the skull can, however, be limited by image distortion caused by magnification and superimposition.<sup>5</sup> The location of a soft tissue mass can be very useful in reaching a diagnosis from the list of differentials. For example, a well



circumscribed, round mass of soft tissue opacity in an area of the ethmoid labyrinth, without mineralization is suggestive of a progressive ethmoid hematoma.<sup>2</sup> A mineralized soft tissue opacity in the caudal maxillary sinus is more likely to be a paranasal sinus cyst.<sup>2</sup>

To help separate overlying structures and to evaluate individual teeth apices, oblique views are taken.<sup>2</sup> These views allow a more accurate assessment of the dental radicles and reserve crowns.<sup>41</sup> The cassette is placed on the affected side and the beam is angled at 30 degrees from the vertical towards the maxilla.<sup>43</sup> This view is the most useful for detecting bone sclerosis, loss of the lamina dura and lysis of the normal contour of a particular tooth root.<sup>41</sup> This view also allows assessment of the molar tooth roots for flattening and distortion, which has been a demonstrable finding in cases of paranasal sinus cysts.<sup>4</sup> This view, however, causes fluid within the sinus to lose its definitive horizontal line appearance and instead appears as a soft tissue opacity, which may make it difficult to differentiate fluid from a soft tissue mass. Oblique views must also be obtained of the unaffected side.<sup>41</sup>

Dorsoventral views can be easily achieved in a well sedated standing horse. The x ray beam is angled obliquely from cranioproximal to caudodistal, perpendicular to the plate. The plate is held ventral to the mandible and parallel to it. It is difficult to obtain a true dorsoventral view using this technique, without causing a degree of obliquity, due to the position of the plate and the x ray beam in relation to the horses head.<sup>44</sup> This projection is very useful for showing the degree of nasal septal deviation, for demonstrating extension of sinus disease into the nasal chambers<sup>41</sup> and for evaluating the ventral conchal sinus. This view is particularly useful for evaluating obstructive masses.<sup>41</sup>

Sinus cavities, however, are difficult to evaluate on a dorsoventral view, due to the overlying masseter muscles and cheek teeth which obscure most of the field.<sup>5</sup>

Not surprisingly, radiographic findings associated with sinus cysts overlap with those of other intra sinus masses.<sup>2,45</sup> There is little to distinguish a sinus cyst radiographically from a progressive ethmoid hematoma or a neoplastic mass.<sup>27</sup>

Typically, a sinus cyst presents radiographically as a soft tissue opacity in the paranasal sinus with a characteristically mineralized capsule containing bony spicules. Depending on the cyst size and location, it is possible to appreciate distortion, thinning and demineralization of the frontal and maxillary bones and, on a dorsoventral view, deviation of the nasal septum.<sup>2,41</sup>

Each of the different paranasal sinus diseases have soft tissue radiographic changes, which are indicative, but not pathognomonic, of that particular disease.<sup>2</sup> The findings of radiographic examination must, therefore, be taken in context with all other findings, to prevent confusion and misdiagnosis. A tumor, for example, can appear radiographically very similar to a sinus cyst.<sup>44,46</sup> A fluid line, moreover, does not necessarily mean a primary sinusitis, if other abnormalities indicate a sinus cyst. In such a case, the fluid line could be due to a secondary sinusitis, physical obstruction of the nasomaxillary opening<sup>10</sup> or possibly due to a retention mucocoele.<sup>11</sup> Equally, tooth root changes may be caused by a tooth root infection but, if accompanied by signs typical of a sinus cyst, the tooth changes may be secondary to the cyst or, conversely, may be the cause of the cyst.<sup>4,25</sup> In cases where there is a nasal component, endoscopy can provide additional information but in the vast majority of cases definitive diagnosis depends on surgical and pathological findings.<sup>4</sup>

Fluid and tissue samples may, therefore, be required to confirm a diagnosis.<sup>47</sup> This can involve performing cytology, bacterial culture and sensitivity and histopathology on the samples obtained. This can be achieved by either needle centesis or trephination or at the time of surgery.<sup>5</sup> Thinning of the bone due to an expansive cyst can sometimes be so pronounced that sinusotomy can be made with only a scalpel blade.<sup>2</sup>

Trephination can be used diagnostically, both to aspirate the sinus contents for cytology, culture and sensitivity testing, to perform biopsy, and to provide a portal for therapeutic lavage.<sup>5</sup> This simple procedure is often used when a generalized sinus problem is suspected and is best used when fluid has been identified radiographically.<sup>1</sup>

There are several anatomical trephine sites to choose from. If a generalized sinus problem is suspected, a suitable site is located 3 cm dorsal to the facial crest and 3 cm rostral to the medial canthus.<sup>5</sup> If only the rostral maxillary sinus is thought to be involved, the area chosen is 3 cm dorsal to the facial crest and 3 cm caudal to the infraorbital foramen.<sup>5</sup> The trephine site is clipped and routinely prepared for surgery. 5 ml of local anesthetic is injected to create a skin bleb and to infiltrate the underlying periosteum. Once a trephine site is chosen, a 1 cm stab incision is made through the skin and periosteum. A steinmann intramedullary pin, 4.76mm or a 6.35mm in diameter is used to penetrate the bone.<sup>5,48</sup> A fluid sample is aspirated. The stab incision is not sutured to reduce the chance for development of cellulitis.

If the horse is seen to have a soft tissue mass on radiographs and has facial distortion, it is acceptable to perform centesis using a 14-16 gauge needle inserted directly over the area of swelling.<sup>4</sup> Although the nature of the fluid contents of sinonasal cysts have received scant attention in the literature,<sup>3</sup> it is generally accepted that the fluid contents

are typically sterile and have cytologic evidence of chronic inflammation and erythrophagocytosis.<sup>13</sup>

In cases in which the results of radiographic examination are uncertain, sinoscopic examination of the paranasal sinuses has been employed subsequent to trephination.<sup>46</sup>

The benefit of this modality is direct visualization of the sinus, thus ruling out the possibility for a lesion or a tooth root infection to be obscured by a fluid line, as may occur with radiographic examination.<sup>46</sup> It also allows differentiation between cystic lesions and other soft tissue masses. This technique, in addition, allows for biopsy of the sinus contents and initiation of limited therapy if required. Biopsy should be obtained to achieve a definitive diagnosis.<sup>10</sup> The preferred site for biopsy of sinus mucosa is the lateral wall of the caudal maxillary sinus, because of its endoscopic and surgical accessibility and easy identification of this site.<sup>10</sup> The presence of rounded, pink/blue mucosal lined structure on sinoscopy would suggest a sinonasal cyst.<sup>2</sup>

Trephination for sinoscopy follows the same principles as trephination for centesis, and can also be performed on standing well sedated horses. Three portal locations can be used: the frontal sinus portal, located 60% of the distance from midline toward the medial canthus and 0.5 cm caudal to the medial canthus; the caudal maxillary sinus portal, located 2 cm rostral and 2 cm ventral to the medial canthus; and the rostral sinus portal, located 50% of the distance from the rostral end of the facial crest to the level of the medial canthus and 1 cm ventral to a line joining the infraorbital foramen and the medial canthus.<sup>11,46</sup> Endoscopic portals are made with a 6.35mm Steinmann pin in a hand held chuck through a 1.5 cm skin incision.<sup>46</sup> Biopsy instruments can be inserted through a second portal or through an enlarged endoscope portal.<sup>5</sup> Endoscopic portals

do not appear to complicate subsequent flap sinusotomy.<sup>46</sup> The portals, however, should be allowed to heal before subsequent surgery, as they can predispose to fracture and/or necrosis of the bone flap.<sup>5,46</sup> Lesions definitively diagnosed using sinuscopy include: progressive ethmoid hematomas; sinus cysts; neoplasia; tooth root abnormalities; sinusitis; fungal infections and orbital floor fractures.<sup>5</sup> It should be noted that sinus endoscopy provides only limited exposure to the rostral maxillary or ventral conchal sinuses.<sup>46</sup>

Other, less commonly employed modalities have been used in the pursuit of a diagnosis of paranasal sinus cysts. These include computed tomography (CT),<sup>49</sup> magnetic resonance imaging (MRI),<sup>50</sup> and nuclear scintigraphy.<sup>51</sup> The great advantage of CT examination of the equine skull is elimination of the superimposition present with conventional radiographs.<sup>52</sup> The advantage of MRI is its superior soft tissue detail, increasing the specificity of diagnosis, for example, distinguishing a sinonasal cyst from neoplasia. However, MRI has little value in assessing bone erosion and sinus configuration.<sup>50</sup> Both CT and MRI are not, however, universally available, require a general anesthetic and are costly.

Published reports on the use of scintigraphy to aid diagnosis of paranasal sinus disorders have been limited to small numbers of horses.<sup>53</sup> Results show that quantitative analysis of scintigrams are not reliable for identification of particular disorders,<sup>51</sup> although, it has been shown that scintigraphy can be useful for differentiation of sinusitis of dental origin from other causes of sinusitis.<sup>51</sup>

Sinonasal cysts typically require surgical excision, due to their tendency for bone destruction and continued expansion.<sup>53</sup> There have been no reports of spontaneous regression.<sup>7</sup> The use of a trephine hole approach to treat sinus cysts has been described.<sup>46</sup> Due to the poor visibility achieved during this procedure, however, and the possibility of requiring multiple trephine holes, it has been advocated by some that trephination is best used as a diagnostic tool for obtaining samples for cytology, biopsy or culture, rather than as a method of treatment.<sup>53,54</sup> Incomplete removal of cystic membranes because of poor exposure through a trephine opening is thought to result in recurrence of obstructive nasal disease.<sup>23</sup>

It has been demonstrated that small sinus cysts can be removed by way of sinuscopy through a combination of debridement, lavage and suction. This technique seems to be very well tolerated by the horse.<sup>46</sup> However, it is recommended that this technique be reserved for very small cysts.<sup>46</sup> If doubt exists as to the extent of sinus involvement, a bone flap approach should be used. Frontomaxillary or maxillary flap surgery is required for extensive excisional procedures such as removal of sinus cysts.<sup>53</sup>

The lateral maxillary sinus approach provides good access to the maxillary sinus only, providing limited access to the sphenopalatine and conchofrontal sinuses.<sup>12,55</sup> This restricted access is of importance because of the common involvement of these latter sites in the disease process. Also, in young horses this approach can lead to difficulties in accessing the ventral conchal sinus due to the prominent reserve crowns of the cheek teeth, which reduce the space dorsal to the infraorbital canal where access to the ventral conchal sinus is granted.<sup>55,56</sup>

There are a number of techniques described for frontonasal flap surgery, including a triangulated flap technique,<sup>57</sup> a modified standing frontonasal flap technique<sup>58</sup> and a method described here for a large frontonasal flap performed under general anesthetic.<sup>55</sup> It is suggested that some commonly involved sites are not adequately exposed using the triangulated flap technique and, for this reason, it is not popular.<sup>55</sup>

The large frontonasal flap technique is said to improve access to sites, most commonly affected such as the ventral conchal sinus and both maxillary sinuses.<sup>55</sup>

The large frontonasal flap allows surgical access to the ethmoturbinates, the dorsal conchal sinus, the ventral conchal sinus, the caudal compartment of the maxillary sinus, the sphenopalatine sinus (indirectly), the turbinates and the nasal chambers.<sup>54</sup>

In older horses, with less reserve crown root, this flap can also allow access to the rostral compartment of the maxillary sinus.<sup>54</sup>

The procedure is most commonly performed under general anesthesia, but a standing modified frontonasal flap technique has been described in the literature.<sup>58</sup> The outcome for both techniques is comparable.<sup>58</sup> Obviously the standing procedure negates the need for general anesthesia and its inherent risks. Tissues in standing patients are less engorged, a fact that can lead to a reduction in hemorrhage, a much improved surgical view and consequently reduced surgery time.<sup>58</sup> Care must be taken, however, if performing the procedure with the horse standing, as accidental manipulation of the infraorbital nerve will cause a violent reaction.<sup>58</sup> It is generally accepted that standing surgeries should be reserved for docile patients.<sup>59</sup>

Paranasal sinus surgery can be prolonged, however, and there are advantages to having the patient recumbent.<sup>54</sup> The main advantage being the immobility of the

patient and increased exposure to the surgical field. For this reason, the modified standing method should be reserved for disease early in its onset, where the lesions may be smaller.<sup>58</sup>

To perform a frontonasal flap under general anesthesia the horse is intubated and the endotracheal cuff is inflated. The aim is to protect the lower airway from inhalation of blood, pus and surgical debris. The horse is positioned in lateral recumbency with the affected side up. The head should be tilted to enhance drainage through the nose, which is dependent.<sup>54</sup>

The frontal, nasal and maxillary areas of the face are clipped from the poll to the nasoincisive notch and routinely prepared for aseptic surgery. A contoured skin incision is made to follow the pattern of the bone flap. The outer limits for the flap are the midline, the level of the supraorbital foramen caudally and the end of the facial crest rostrally. The lateral limit begins 2 cm medial to the medial canthus of the eye and follows the bridge of the nose.<sup>54</sup> The lateral extent of the flap should be created to ensure as wide a flap as possible, whilst remaining medial to the nasolacrimal duct. The course of this duct is regarded as a line from the medial canthus of the eye to the nasoincisive notch.<sup>55</sup> The position of the lateral border of the flap differentiates this technique from the triangular flap technique whose lateral border follows the outline of the conchofrontal sinus closely. The periosteum is incised along the same contour as the skin, but inset 2-3mm. This staggered incision allows skin and periosteal repair to be supported by bone during healing.<sup>3</sup>



The frontal bone can be cut using a hand drill, flat osteotome and mallet<sup>54</sup> or using an oscillating saw.<sup>55</sup> It has been suggested that power equipment can lead to a loss of bone substance, resulting in a poor fit when the flap is replaced.<sup>54</sup>

Discrepancy exists in the literature as to whether beveling the edges of the bone margins is necessary or not. It has been proposed that beveling aids repositioning of the bone flap.<sup>54</sup> There is also debate as to whether the bone plate should be replaced or discarded. Some authors suggest that discarding the bone flap can lead to a cosmetic blemish, whilst others argue that replacing the flap can lead to a higher risk of infection.<sup>53</sup> It is advisable to discard the flap if it is thin or crumbly, rather than replace it and risk subsequent sequestration. When the flap is not replaced, the remaining periosteum should generate new membranous bone over the defect.<sup>54</sup>

The flap is pried upwards (fractured) to form a 'hinge' on the dorsal border (midline) to expose the sinus. The reflected flap should be kept covered and moistened with warm physiologic saline solution throughout the surgery. Where possible, the skin, periosteum and bone should be reflected as a single unit as it has been suggested that dissection of the skin and fascia from the bone can predispose to hematoma formation and cellulitis, whilst offering no advantages.<sup>54,55</sup> The flap allows direct visualization of the conchofrontal sinus, ethmoid labyrinth and the frontomaxillary opening. The frontomaxillary opening allows access to the caudomaxillary sinus and the sphenopalatine sinus.<sup>55</sup> The floor of the frontal sinus and dorsal conchal sinus can be opened using scissors or Ferris Smith rongeurs to expose the middle nasal meatus, caudal part of the nasal passages and ethmoturbinates. If needed, the ventral concha,

the conchal bulla and the bony septum can be removed to allow access to the rostral maxillary sinus and the ventral conchal sinus.<sup>55</sup>

If the cyst is penetrated during the approach, the remaining cyst fluid is aspirated and the cyst lining is then peeled away from its attachments to the walls of the sinuses by using a combination of traction and digital elevation.<sup>3</sup>

Total extirpation of the cyst lining is rarely possible but, according to most authors, partial extirpation does not lead to a higher rate of recurrence of the cyst.<sup>4</sup> It is suggested that this remaining lining may, in fact, be advantageous to the surgeon by overlying and protecting important anatomical structures such as the infraorbital canal.<sup>3</sup> It is believed that any residual secretory epithelium drains to the nasal meati via the sinonasal drainage ostium.<sup>3</sup>

Following removal of the cyst, adequate nasomaxillary drainage should be established.<sup>5</sup> Drainage openings into the nasal chambers should be enlarged by trimming away redundant turbinate mucosa.<sup>55</sup> Fistulae can also be made by removal of sections of the floor of the conchofrontal sinus or the medial wall of the ventral conchal sinus, to allow free communication between the sinus cavities and the nasal meati.<sup>55</sup> Additional drainage can be achieved from the caudal maxillary sinus by removal of the septum dividing it from the rostral maxillary sinus.<sup>55</sup> Creation of these openings should be performed as the final component to surgery, due to the profuse hemorrhage that can result.<sup>55</sup> It should be remembered, however, that although the creation of sinonasal fistulae prevents gross fluid accumulation, it does not restore normal anatomy to the sinus. Normal ciliary action continues to cause mucus to flow unidirectionally towards the natural sinonasal ostia, which do not lie at the lowest points in the sinuses.

Therefore, the success of iatrogenic drainage relies on the positioning of the surgically created ostia.<sup>60</sup> The creation of an unnatural drainage ostium can also affect the normal sinus defense mechanisms and may increase the susceptibility of the sinuses to a secondary infection.<sup>5,27</sup> In the human literature, it has been shown that sinuses have high levels of nitric oxide, which is documented to have an antibacterial activity. It is possible that surgical creation of an ostium could alter the physiologic levels of nitric oxide and compromise the sterility of the paranasal sinuses.<sup>61</sup> To this author's knowledge, this has not been evaluated in the horse. Resolution of clinical signs without the creation of a naso-sinus ostium has been reported, and has brought into question the validity of the common practice of creating an ostium for drainage of paranasal sinuses into the nasal cavity.<sup>59</sup>

It is recommended that lavage with either physiologic saline solution or povidone iodine solution should be undertaken routinely to decrease post surgical infection due to the unavoidable debris remaining after the surgery. Irrigation allows physical displacement of this debris.<sup>53</sup> A foley balloon catheter can also be implanted into the caudal maxillary sinus and led out of the ventral nasal meatus, thus providing a convenient post surgical irrigation and medication route.<sup>53</sup> The catheter can alternatively be led out of a trephine hole.<sup>4</sup> It has been shown, however, that overzealous lavage post surgery can have a deleterious effect, causing incisional dehiscence.<sup>58</sup>

If the bone flap is to be replaced, it is repositioned and the soft tissues closed with a three layer approach using 2-0 polydioxanone in the periosteum and the dermis, for example, and size 2-0 polypropylene in the epidermis.<sup>54,55</sup> If the bone flap is deemed to

be unstable it can be sutured in place with 2 or 3 simple interrupted sutures of size 1 polydioxanone or surgical wire, placed through pre drilled holes.<sup>54</sup>

Disruption of the nasolacrimal duct, the periocular muscles and the supraorbital nerves are all possible complications when working in this area. A thorough knowledge of the anatomy of this area is, therefore, essential before surgery is attempted.<sup>57</sup>

Due to the highly vascular nature of the anatomy, hemorrhage is one of the greatest complications of this type of surgery. One of the advantages of performing the surgery in a standing horse is the reported reduction in the amount of hemorrhage. The postural changes in the anesthetized horse seem to exaggerate the problem.<sup>58</sup>

Temporary occlusion of the carotid arteries has been suggested as a means of controlling intra operative hemorrhage.<sup>55,58</sup> However, risk of injury to the recurrent laryngeal nerve should be considered before contemplating this technique, especially as the clinical results of actually reducing hemorrhage are reported to be variable.<sup>5</sup> Some authors suggest finding an appropriate blood donor pre surgery. Others even advocate collecting a minimum of eight liters of whole blood in acid citrate dextrose anticoagulant from a compatible donor pre surgery.<sup>57</sup>

'Sock and Bandage' packing can be used post operatively to help control hemorrhage.<sup>53,55</sup> The bandage consists of lengths of cotton bandage packed into tubular stockinette socks, the open end of the stockinette is led to the nostril where it is sutured with a mattress suture to the false nostril. On the third or fourth day post surgery, the bandage material is withdrawn and a few days later the stockinette is removed.<sup>53</sup> The purpose of the stockinette sock is to prevent migration of the cotton packing into the pharynx, where it could be swallowed.<sup>5</sup> Alternatively, all exposed cavities can be

accordion-fold packed with tubular gauze.<sup>54</sup> Using either technique the packing not only aids in hemostasis, but also helps maintain and dilate the newly created sinonasal fistulae.<sup>4,53</sup> One final complication of sinus cyst surgery is reduced nasal airflow which is of particular importance to the horse, as an obligate nose breather. Nasal airflow reduction post surgery is usually due to hydrostatic pooling of blood on the dependent side and can be severe enough to necessitate tracheostomy tube placement, at least until the packing is removed.<sup>6</sup>

Other complications associated with the frontonasal bone flap are usually minor and short lived. They can include: incisional discharge; skin suture abscess; skin wound dehiscence along the rostral border<sup>55</sup> and opportunistic mycotic infections at the site of cyst removal.<sup>3</sup> Epiphora has also been reported post surgery, caused by a fracture of the lacrimal bone at a point distant to the flap.<sup>5</sup>

It is desirable to perform an endoscopic examination of the sinus contents 30-60 days post operatively. This can be achieved per nasum through the iatrogenic fistulae created during surgery.<sup>53</sup>

Prognosis for paranasal sinus cysts following surgical removal is generally good.<sup>3,4,10,58,62</sup> A chronic nasal discharge may persist post surgery, likely initiated by the remnants of unremoved cyst lining, from a secondary infection, or from the creation of an inadequate drainage ostium at the time of surgery.<sup>5,53</sup> An early return to exercise has been advised by some authors: the forced nasal ventilation is thought to cause evaporation of residual discharge and therefore decrease the chance for infection.<sup>53</sup> In young growing horses, there are reports of resolution of nasal obstruction and facial distortion following successful removal of the sinus cyst.<sup>13</sup> One study reported no cyst

recurrence in 34 horses that had sinus cysts removed surgically.<sup>62</sup> Another report described 45 out of 48 horses with complete resolution of clinical signs following cyst extirpation using an osteoplastic flap technique such as described here.<sup>3</sup> Recently it has been reported that reopening a sinus flap incision in a controlled environment in the standing horse, on average 3 days post surgery, can help to reduce long-term complications and recurrence rates.<sup>63</sup> This technique may be particularly useful where significant hemorrhage develops at the initial surgery, resulting in reduced visibility.<sup>63</sup>

#### **CLINICAL REPORT:**

An 18 month old Thoroughbred colt presented with a 3 month history of discharge from the left nostril, and a more recent history of stertorous breathing and facial deformity. The owner had treated the horse on one occasion with sulfamethoxazole-trimethoprim tablets (30mg/kg PO q12hrs) for a period of 14 days. The nasal discharge had reduced significantly but returned once the medication was discontinued.

The colt had previously received veterinary attention for routine herd health but had no previous significant medical issues.

On physical examination, the colt was bright, alert and responsive. He had a body condition score of 5 (1-9 AAEP scale). There was a mucopurulent discharge from the left nostril and a convex deformity over the left maxillary sinus which obscured the facial crest. Reduced airflow could be appreciated from the left nostril. The frontal and maxillary sinuses on the left side were dull on percussion.

The problem list for this horse included unilateral mucopurulent nasal discharge, facial deformity and stertorous breathing.

The important differential diagnoses for each of the presenting signs were as follows:

- 1) Unilateral nasal discharge: primary sinusitis, dental sinusitis, sinus cysts, sinonasal neoplasia, progressive ethmoid hematoma, sinonasal trauma, sinonasal mycosis, rostral maxillary cheek tooth infection, sinonasal polyp, foreign body, guttural pouch infection.
- 2) Mucopurulent non malodorous nasal discharge: primary sinusitis, sinus cysts, sinonasal neoplasia.
- 3) Facial deformity: sinonasal neoplasia, sinus cysts, dental sinusitis, trauma.
- 4) Nasal airflow obstruction/stertorous breathing: sinonasal growths, progressive ethmoid hematomas, sinus cysts, sinonasal tumors, sinonasal polyps, trauma, foreign body.

The most likely differential diagnoses, given the combined clinical signs, included a paranasal sinus cyst, neoplasia or a progressive ethmoid hematoma.

Subsequent to obtaining a detailed history and performing a thorough full body physical examination, endoscopic examination was performed using a 1 meter videoendoscope.<sup>a</sup>

The meati of the left nostril were extremely narrowed, the nasal mucosa was inflamed and swollen and it was very difficult to pass the endoscope through any of the meati to evaluate the pharynx from the left side. A mucopurulent discharge, however, was evident at the caudal aspect of the middle meatus. The sinonasal drainage ostium was obscured by the pus. Bacterial culture of this discharge, performed in house, yielded a mixed growth of commensal bacteria (Table 1). The diameters of the nasal meati in the

<b>Diagnostic Test</b>	<b>Discharge from nasal cavity sampled at time of endoscopic examination</b>	<b>Discharge from sinus surrounding cyst sampled at surgery</b>
<b>Gram's Stain</b>	Gram +ve cocci Gram +ve rods Gram -ve rods	gram +ve cocci gram +ve rods gram -ve rods
<b>Aerobic microbial culture</b>	Mixed growth of commensal bacteria	Mixed growth of commensal bacteria
<b>Anaerobic microbial culture</b>	Not performed	No growth

Table 1: culture results obtained from mucopurulent discharge during initial endoscopy and subsequent surgery.



right nasal passage were decreased with mild deviation of the nasal septum from the left side. The guttural pouches and trachea were examined and appeared free of exudate. Arytenoid function appeared normal.

The colt was sedated with detomidine<sup>b</sup> (0.01mg/kg IV) and butorphanol tartate<sup>c</sup> (0.05mg/kg IV) and a thorough oral inspection was performed with a Hausmann gag<sup>d</sup> in place. No abnormalities were observed.

Skull radiographs were subsequently obtained using a portable digital x ray machine<sup>e</sup> (lateral, right and left 30 degree obliques, dorsoventral projections). The major finding was a large soft tissue density mass associated with the frontal, conchofrontal and maxillary sinuses on the left side. This was most easily visible on the dorsoventral view (Figure 2).

The dorsoventral view also revealed deviation of the nasal septum to the right, by a structure with a partially mineralized well defined capsule.

Further diagnostics included routine blood chemistry and hematology analysis performed in house. The results indicated a mild anaemia with a hematocrit of 29% (normal 32-52%). The remainder of the biochemistry and hematology values were within normal limits (Table 2).

Due to the facial swelling and corresponding discrete soft tissue mass observed radiographically, centesis of the lesion by way of needle aspiration was performed. The horse was placed in stocks and sedated with detomidine<sup>b</sup> (0.01mg/kg IV) and butorphanol tartate<sup>c</sup> (0.05mg/kg IV). The horses head was supported on a stand and the area over the facial swelling was clipped and aseptically prepared. A bleb of local anesthetic solution was placed subcutaneously and a steel 14 gauge hypodermic



Figure 2: Dorsoventral skull radiograph depicting a soft tissue density mass with a mineralized capsule (black arrow). Septal deviation is highlighted by white arrows.

TEST	RESULT	REFERENCE RANGE
White blood cell count	8.8	7.200-12.500/ UL
Red blood cell count	8.28	6.50-12.50 x 10 <sup>6</sup> /UL
Hemoglobin	10	11-17 gm/dl
Hematocrit	28.6	34-50%
Segmented Neutrophils	64	30-75%
Band Neutrophils	0	0-1%
% Lymphocytes	32	25-60%
Monocytes	4	1-8%
Eosinophils	0	1-2%
Platelet Estimate	253	200-400 x 10 <sup>3</sup> /UL
Total Protein	5.8	5.6-7.2g/dl
Fibrinogen	400	200-400mg/dl
TEST	RESULT	REFERENCE RANGE
Sodium	136	132-146 mmol/L
Potassium	4.1	2.4-4.7mmol/L
Chloride	100	95-104mmol/L
Aspartate Aminotransferase	236	226-365U/L
Creatinine Kinase	95	1-225U/L
Blood Urea Nitrogen	6	10-24mg/dL
Creatinine	1.2	0.7-2.0mg/dL
Alkaline Phosphatase	250	143-395U/L
Total Bilirubin	1.1	0-2.0mg/dL
Gamma-glutamyl transferase	12	0-36U/L
Calcium	11	10.7-13.5mg/dL
Albumin	3.2	2.3-3.9g/dL
Phosphorus	4.2	2.3-5.4mg/dL
Total Protein	5.7	5.6-7.9g/dL
Glucose	86	75-115mg/dL

Table 2: Horse blood biochemistry and hematology results

needle was driven through the maxillary bone. The needle was positioned over the most prominent area of facial swelling.

Approximately 60 ml of a viscous translucent, odorless yellow fluid was retrieved and placed in a plain sterile vacutainer (Figure 3) and an EDTA vacutainer and sent for cytology, and culture and sensitivity. These tests were performed in house. Cytology and culture results identified a sterile proteinacious fluid containing erythrocytes but with a predominance of neutrophils (Table 3). Aerobic and anaerobic culture of the fluid sample were performed in house and yielded no growth after seven days.

Based on the history, clinical findings, endoscopic, radiographic and findings from centesis, a presumptive diagnosis of a paranasal sinus cyst was made. Although neoplasia could not be ruled out, it seemed less likely given that the fluid obtained during centesis was characteristic for a paranasal sinus cyst. However, the diagnostic tests were not conclusive and, therefore, a refined differential list was compiled to include a paranasal sinus cyst and neoplasia.

With the knowledge that the lesion was probably too large to successfully extirpate through a sinoscopy portal and with a high suspicion for the diagnosis of a sinonasal cyst, the owner elected to confirm the diagnosis and remove the mass at the same time by way of a frontonasal flap procedure. Due to the horse's young age and his fractious nature, it was decided to perform the frontonasal sinus flap with the horse under general anesthesia.

A 14 gauge short term catheter<sup>f</sup> was used to cannulate the left jugular vein. Tetanus antitoxin,<sup>g</sup> (10,000IU IM) was administered in addition to pre operative antibiotics:

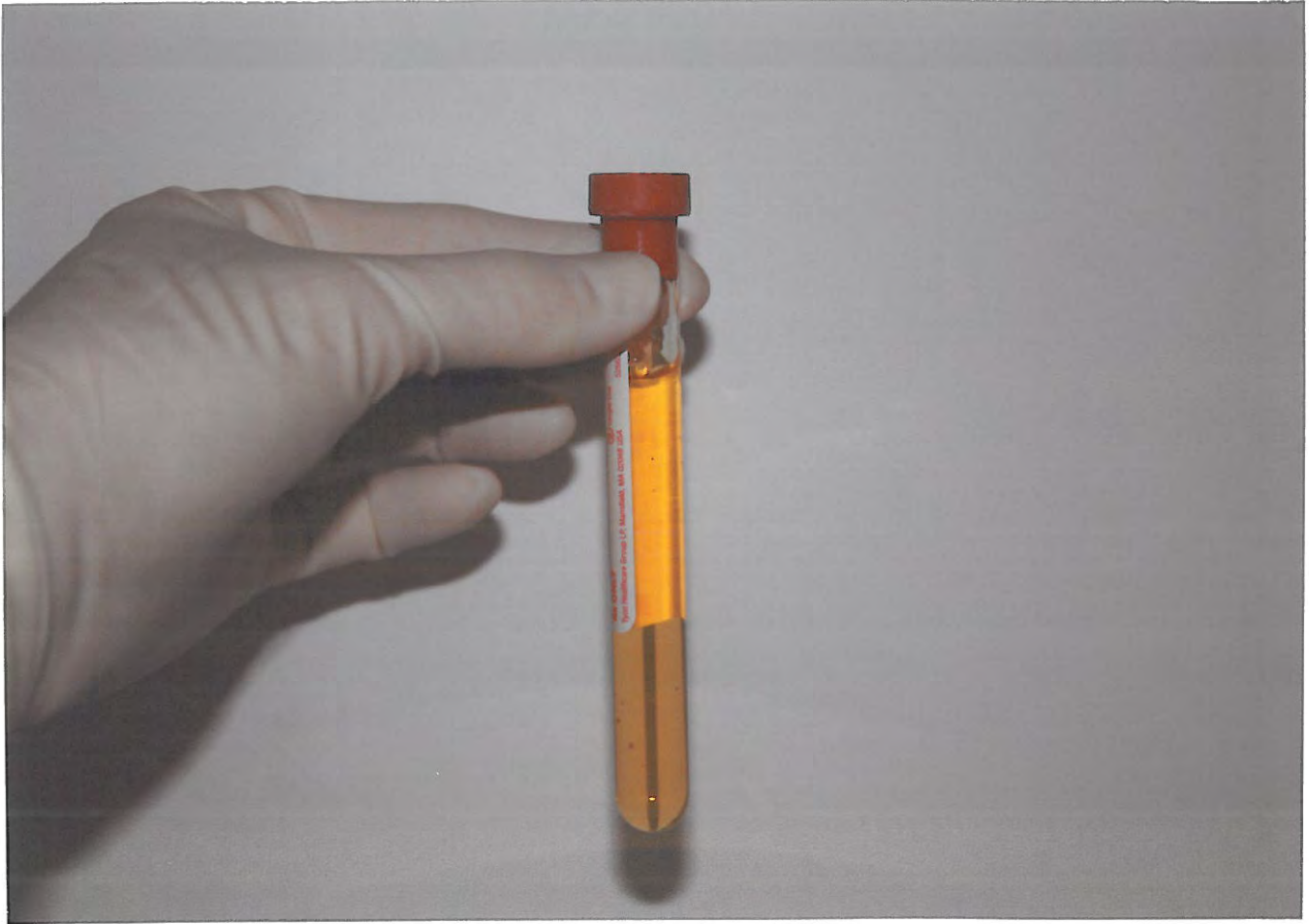


Figure 3: Sterile vacutainer containing characteristic translucent honey colored fluid obtained from centesis of the maxillary sinus.

<b>Diagnostic Test</b>	<b>Test value</b>	<b>Reference range</b>
<b>Total Protein g/L</b>	125	N/A (not applicable)
<b>Total White Blood Cell Count</b>	$19.7 \times 10^9/L$	N/A
<b>% Neutrophils</b>	83	N/A
<b>Anaerobic culture</b>	Negative at 7 days	N/A
<b>Aerobic culture</b>	Negative at 7 days	N/A

Table 3: Sinocentesis cytology and culture results.

procaine penicillin G,<sup>h</sup> (22,000IU/kg IM); Gentamicin sulfate,<sup>i</sup> (6.6mg/kg IV).

Phenylbutazone<sup>j</sup> (2.2mg/kg IV) was also administered pre operatively. The horse was given xylazine<sup>k</sup> (0.8mg/kg IV) and general anesthesia was induced with diazepam<sup>l</sup> (0.1mg/kg IV) and ketamine<sup>m</sup> (2mg/kg IV). The horse was intubated, using a size 22 tube and the endotracheal tube cuff<sup>n</sup> was inflated. The horse was maintained on Isoflurane<sup>o</sup> with oxygen on a semi closed circle ventilator. Lactated Ringers solution<sup>p</sup> was administered intravenously throughout surgery at a rate of 10ml/kg/hr.

The horse was positioned in lateral recumbency with the affected side up. The dorsal and lateral aspects of the face were prepared for aseptic surgery.

A large frontonasal bone flap approach was used. The bone flap was approximately 8 cm wide by 10 cm long and a mallet and osteotome were used to create the flap (Figure 4). The bone flap was hinged on the midline and the reflected bone flap was covered with moistened sterile towels throughout the surgery. Upon removal of the flap, a cystic structure was observed which occupied most of the caudal maxillary sinuses and extended into the left frontal sinus via the frontomaxillary opening (Figure 5). On reflection of the frontonasal bone flap, malodorous mucopurulent exudate was also observed within the sinuses. Aerobic and anaerobic culture of this exudate was performed in house and yielded a mixed growth of commensal bacteria (Table 1). The cyst contained yellow, clear fluid similar to that previously obtained by centesis. The delineation between the frontal and maxillary sinus cavities was no longer apparent. The cyst was removed by 'finger fracture', which involved peeling it away from its attachment to the walls of the sinuses using a combination of digital elevation and traction. It was not possible to remove the cyst in one piece. Removal of the rostral

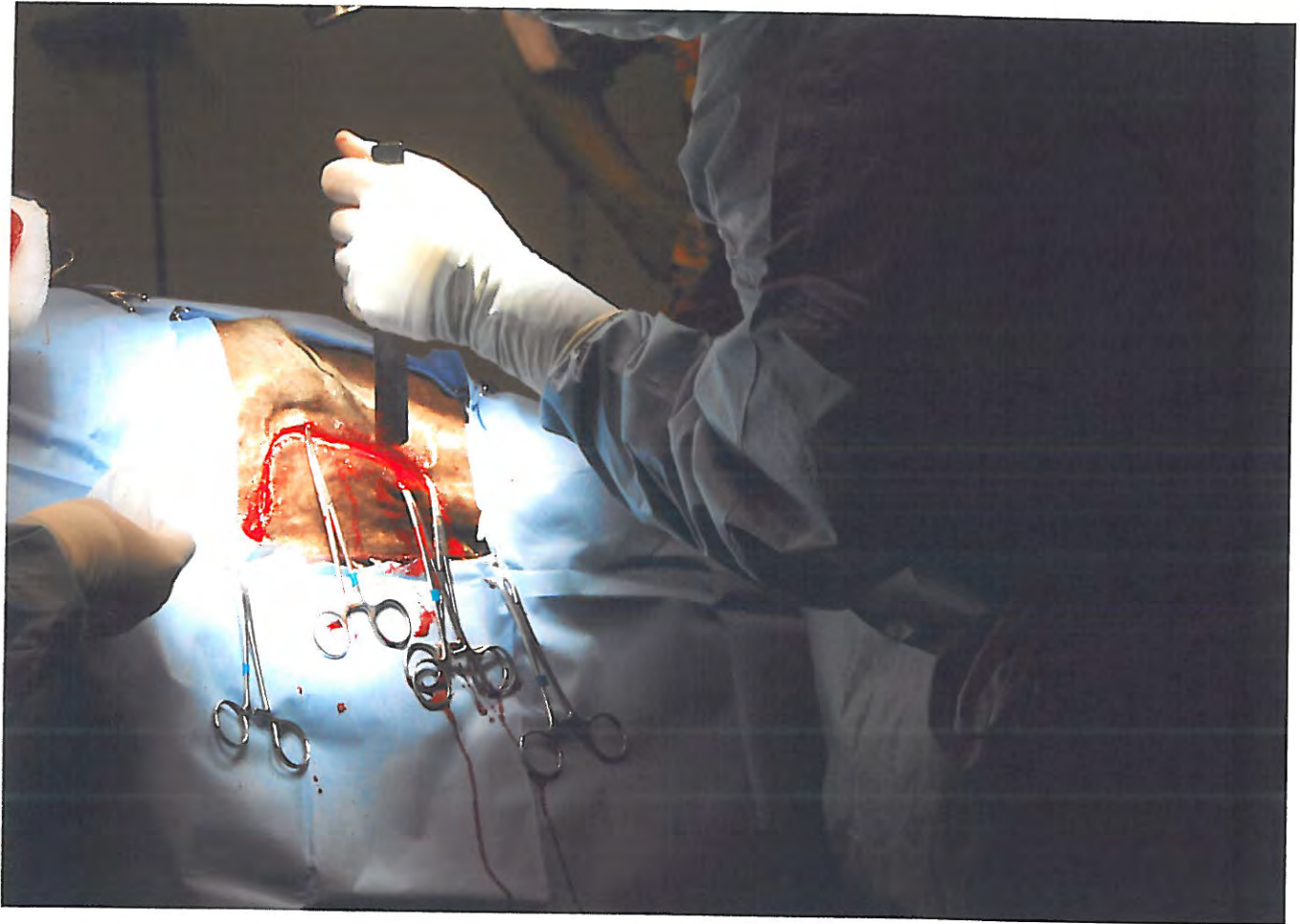


Figure 4: Intra-operative photograph depicting the surgical approach for a frontonasal flap and the use of hand tools to create the flap.



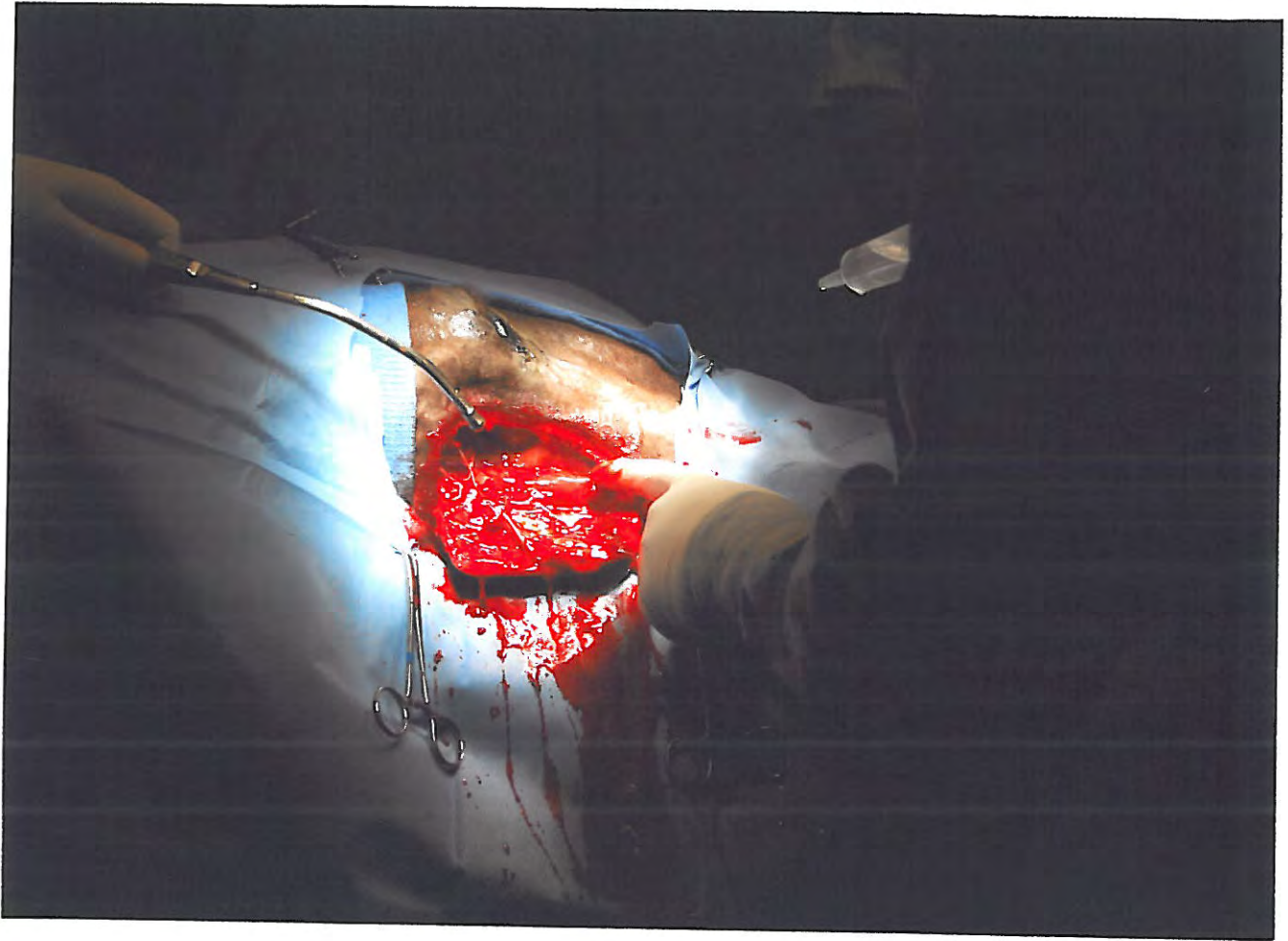


Figure 5: Intra-operative photograph looking into the frontal sinus, through the large frontal flap (reflected).

portion of the cyst was attempted first, to allow placement of packing to control hemorrhage. The sinus mass was placed in 10% formalin and sent to an outside laboratory for histopathology. Suction and lavage were used continually throughout surgery, and once the bulk of the cyst was removed, the sinuses were lavaged copiously with physiologic saline and sponge forceps were used to debride and examine for remaining membrane and to evaluate the sphenopalatine sinus for any remnants of the cyst. Forceps were used to create an opening in the rostral floor of the frontal sinus, to establish communication with the middle nasal meatus. An opening into the nasal passages was also created by partial removal of the medial wall of the ventral conchal sinus. Once a sufficient fistula had been created, the sinuses were packed, with moistened gauze (Figure 6). The free end of the gauze leading from the sinuses and hanging out of the nostril was sutured to the inside of the roof of the false nostril, with a mattress suture.

The bone flap was replaced and sutured in place with three 18 gauge stainless steel wire sutures,<sup>q</sup> placed through pre drilled holes. The subcutaneous tissue and skin were closed routinely, using 2-0 poliglecaprone 25<sup>r</sup> and a simple continuous pattern. The skin was apposed using staples<sup>s</sup>. A non adherent dressing was placed over the flap and secured with adhesive tape.<sup>t</sup> The horse was extubated with the cuff partially inflated, to prevent debris from surgery from being inhaled. The horse had an uneventful recovery from anesthesia.

A tracheostomy tube<sup>u</sup> was placed once the horse was recovered and in his stall.

The gauze packs were removed after 48 hours. The tracheostomy tube was removed after 48 hours. The horse was discharged from the hospital 72 hours post surgery. He

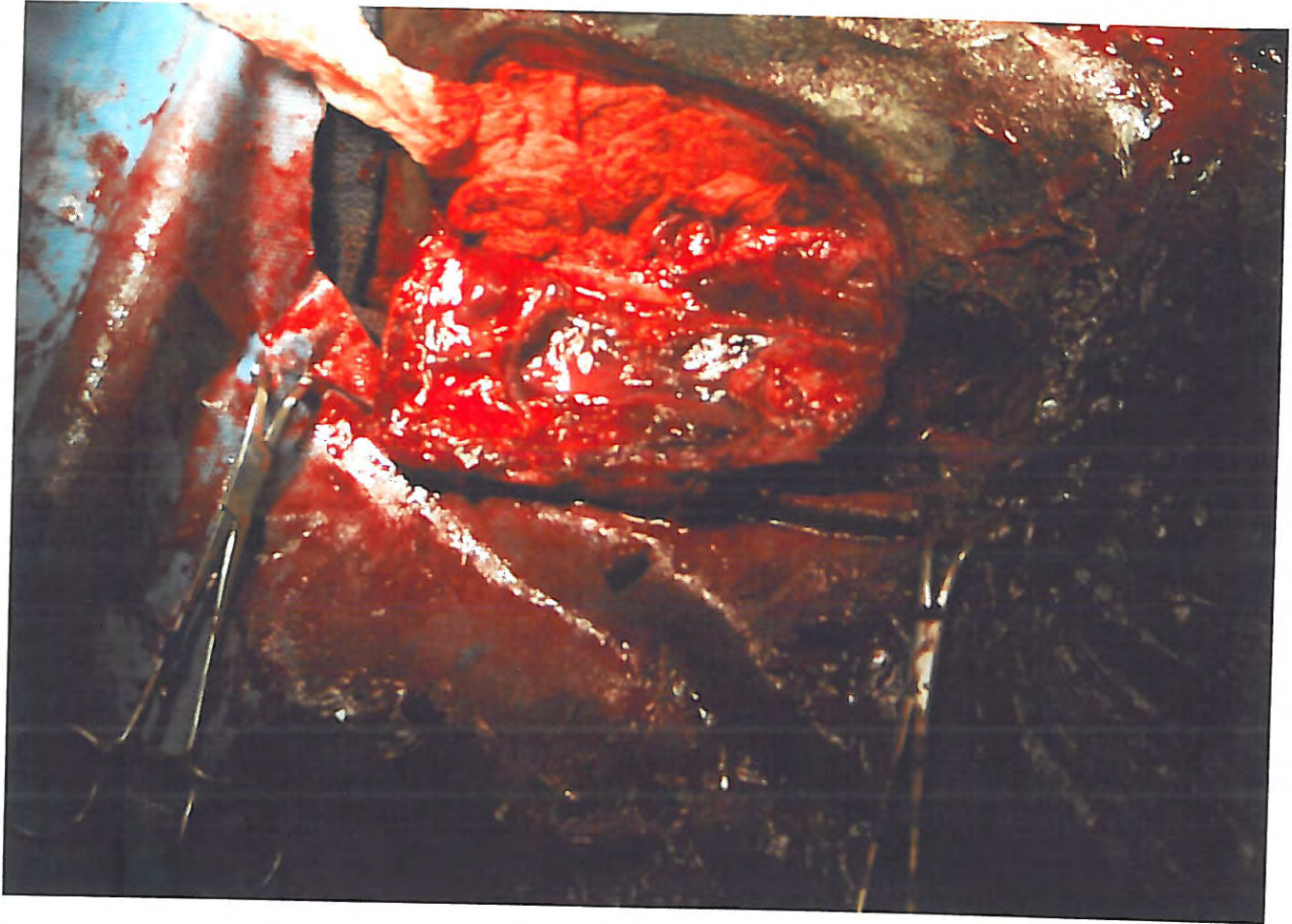


Figure 6: Intra-operative photograph depicting packing of the sinus with moistened gauze packing.

was provided analgesia via phenylbutazone<sup>v</sup> (2.2mg/kg PO q24 hrs) for 5 days and received antibiotic coverage with sulfamethoxazole-trimethoprim tablets<sup>w</sup> (30mg/kg PO q12hrs) for 5 days.

Histopathologic examination of the removed mass identified an ulcerated respiratory epithelium with granulation tissue proliferating in the ulcer bed maturing to fibrous connective tissue in deeper layers. Subepithelial hemorrhage and hemo-siderophages were observed in the wall. Respiratory epithelium was observed in both the interior and exterior of the cyst. A thick fibrous capsule was evident and spicules of trabecular bone were demonstrated. Histopathology, therefore, conclusively confirmed the diagnosis of a paranasal sinus cyst (Figure 7).

The skin staples were removed 14 days post operatively, and the tracheostomy site was allowed to heal by second intention, being cleaned daily with moistened gauze.

The horse was confined to a box stall with hand walking only for 30 days.

Nasal discharge had ceased 30 days post surgery. Recurrence of signs was not evident at the 60 day endoscopic evaluation. Due to the iatrogenically created fenestration of the floor of the conchofrontal sinus, direct endoscopic visualization into the sinus was possible. Blemishes were not detectable at the surgery site and facial distortion was resolving by the 6 month evaluation, as was the deviation in the septum as assessed by endoscopy.

It should be noted that the author was assisted during the surgical removal of the paranasal sinus cyst by a board certified surgeon. The author was scrubbed in during surgery and performed the procedure under the guidance of the surgeon.

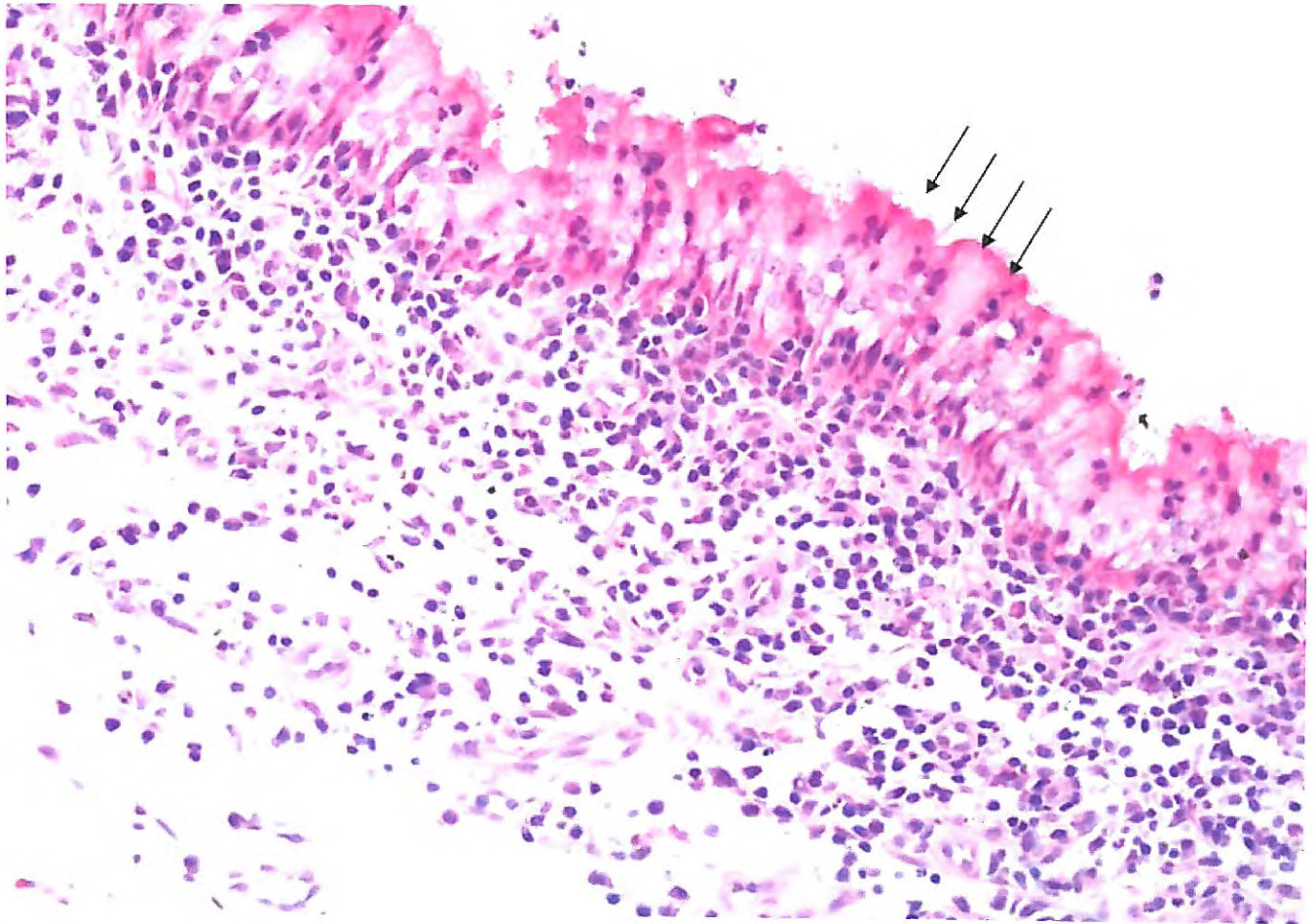


Figure 7: Histology slide. The section demonstrates typical ciliated columnar epithelium (black arrows). H&E stain x 100.

## **DISCUSSION:**

This case report of an 18 month old Thoroughbred colt represents a case of a paranasal sinus cyst of unknown etiology that was positively diagnosed through a combination of modalities and treated successfully with surgery.

The history in this case suggested sinonasal disease. The brief resolution of clinical signs following antibiotic therapy initiated, by the owner, before referral suggested a secondary sinusitis. The delay in seeking veterinary examination is, in this author's experience, typical for cases of sinus disease, mainly due to the ambiguous clinical signs.

The unilateral nasal discharge and the dyspnea observed indicated an expansile mass of some sort. Of the possible differential diagnoses generated, the young age of the patient increased the suspicion of a sinus cyst over, for example neoplasia.

Upper airway endoscopy was useful to confirm the sinuses as the source of the nasal discharge and, to suggest the presence of a space occupying lesion.

Radiography demonstrated a soft tissue mass and septal deviation which supported the diagnosis of a sinus mass. The dorsoventral view, showing a thick capsular structure was suggestive of a paranasal sinus cyst. Radiography was useful for demonstrating the extent of the soft tissue lesion and the apparent lack of tooth root involvement.

Sinocentesis, yielding a sterile yellow fluid, was not pathognomonic of a paranasal sinus cyst but was highly indicative of one.

A definitive diagnosis pre surgery would have required sinuscopy to allow direct visualization and diagnostic biopsy of the mass. Subsequent histopathology of this

biopsy would have confirmed the diagnosis before removal. The option to confirm the diagnosis by performing a biopsy via a sinoscopy portal was offered to the owner, as was the option to perform a sinonasal flap, with the aim of allowing diagnosis and removal of the lesion at the same time. The decision was made to perform a frontonasal flap. Procedures were not undertaken to confirm the diagnosis pre surgery, due to the high index of suspicion for a paranasal sinus cyst and, in this fractious horse, the requirement for a general anesthetic. The perceived benefit of obtaining a definitive pre surgical diagnosis was deemed insufficient to justify the risk of two general anesthetics. In this case, a pre surgical biopsy would not have altered the decision to remove the mass. Regardless of the diagnosis as a tumor or a cyst the owner had requested surgical removal to be attempted. Ultimately, the owner wanted to avoid the possibility of two surgical procedures and, therefore, opted for surgical intervention, without a prior definitive diagnosis.

This decision to perform a frontonasal flap was also influenced by the belief that a sinoscopy portal would not have allowed adequate exposure for removal of such a large mass to be attempted. When considering surgical options, the possibility of aspirating the cyst contents and trying to remove as much as possible by way of lavage and suction as described by Ruggles et al. (1993),<sup>46</sup> was thought inappropriate for what appeared, on radiographs, to be a large mass. The decision was made to perform a frontonasal flap.

Advanced imaging using computed tomography (CT) or magnetic resonance imaging (MRI) would have aided in the differentiation of the mass as a cyst or a tumor prior to surgical intervention. Most importantly, CT would have aided with the identification of

an invasive inoperable tumor pre surgery and in such a case would have spared the horse from a redundant surgery. CT would also have aided with surgical planning and prognostication by allowing determination of the exact extent of the cyst and its association with neighboring structures. Surgical planning would have been improved due to the ability to form a 3 dimensional image from CT scans. MRI with its superior soft tissue detail may have also been able to distinguish a sinonasal cyst from neoplasia. Unfortunately both these modalities require general anesthesia and specialized equipment which can be costly and are not universally available. Both CT and MRI were offered to the owner of this horse, but were declined. It was felt that information gathered from these modalities would not have influenced the decision to undertake surgery in this young horse.

The specific surgical approach was chosen to allow as much access to the involved sinuses as possible. The entire dorsal and lateral side of the face was prepared for surgery, to permit creation of a second approach, such as a lateral maxillary flap, if the rostral portion of the cyst was inaccessible through the frontonasal flap. This was not necessary in this case. The cyst was observed in the caudal and rostral maxillary sinuses and the conchofrontal sinus. Bone destruction, created by the cyst allowed relatively easy access into the rostral maxillary sinus through the frontonasal approach. The bone flap was created using hand held tools, including an osteotome and mallet. The perceived risk of thermal bone damage when using an oscillating saw influenced the choice of instruments.

The corners of the flap were rounded to allow improved vascular supply and to ensure a superior cosmetic appearance. The edges of the flap were beveled to create a better fit



when the flap was repositioned. Once replaced, the flap was sutured in place to create a snug fit, leading to a better cosmetic outcome.

The normal anatomy of the sinuses had been severely disrupted by the expansile nature of the cyst. The septum between the rostral and caudal maxillary sinuses was destroyed. Once the flap was removed, the cyst was observed immediately. The malodorous exudate bathing the cyst was most likely the result of a secondary sinusitis, subsequent to obstruction by the cyst of the drainage angles. Alternatively it could have been the result of a retention mucocoele as described by Woodford and Lane (2006).<sup>3</sup>

It was anticipated that once the obstruction to drainage had been removed, the secondary sinusitis would resolve and this was indeed observed post operatively.

A fistula was made from the ventral conchal sinus into the nasal cavity to ensure adequate drainage. The fistula was enlarged significantly by using the gauze in a sawing motion. The fenestration was performed at the end of surgery, due to the profuse hemorrhage that can result. The sinuses were packed using rolls of gauze, the purpose of which was two-fold. First, to prevent hemorrhage and second, to help maintain patency of the newly created opening into the nasal cavity. An alternative would have been to place an indwelling foley balloon catheter to allow subsequent lavage of the sinuses. The decision not to place an indwelling catheter for lavage was made based on the author's previous successes using packing alone and due to this horse's fractious nature. Because the inciting cause of the secondary sinusitis and a large proportion of the cyst lining had been removed effectively and appropriate fenestration and, therefore, drainage had been established the author was comfortable with this decision.

A tracheostomy tube was placed in this horse once he was back in his stall. The author was uncomfortable with both the stertorous respiration the horse was exhibiting post surgery and with the decreased airflow through the right nostril which had been dependent during surgery. This reduced airflow is typically, due to hydrostatic pooling of blood, on the dependent side. In this horse, however, the majority of the post operative airway restriction was most likely due to the packing in the left nasal passages and the septal deviation partially occluding the right nasal passage. For this reason, it was deemed acceptable to remove the tracheostomy tube once the packing had been removed. One option would have been to place a tracheostomy tube prophylactically before recovery from anesthesia. This would have ensured easier placement of the tracheotomy stoma and avoided the risk of a decrease in airflow. However, pre-surgery, this horse had adequate airflow through his right nostril and in the recovery stall he was determined to be breathing well. Only when this horse had been back in his stall for approximately an hour post-surgery was a respiratory noise heard and a reduction in airflow noted.

A non adherent dressing secured with adhesive tape<sup>t</sup> was used to cover the surgery site. No other form of bandaging was used. This was sufficient to keep the surgery site clean and was not obtrusive to the horse as some more cumbersome head bandages can be. The author has observed horses self traumatize in order to remove head bandages and for this reason such bandaging was not used.

The horse was placed on a course of oral broad spectrum antibiotics: sulfamethoxazole/trimethoprim<sup>w</sup> (30mg/kg PO q 12 hrs). Antibiotic choice was not made based on culture and sensitivity results of the exudate which yielded a mixed

growth of commensal bacteria. Due to the chronic nature of the discharge and the previous antibiotic treatment, the significance of the results of culture and sensitivity was unknown. Tremaine et al. (2000)<sup>2</sup>, reported that samples submitted under such circumstances usually yielded mixed bacterial growths of unknown etiological significance. The antibiotics used in this case were, therefore, to aid against infection of the incision, rather than to treat the sinuses. The nasal discharge was presumed to be self limiting once the cyst was removed as the inciting cause and an acceptable drainage angle was created.

The initial mild anemia was considered secondary to the chronic disease process. It was not monitored for resolution with further hematological analysis due to the positive clinical progress of the patient.

The horse had a mild left sided nasal discharge which resolved within 30 days of surgery. Freeman (2003)<sup>5</sup> has demonstrated this post surgical drainage to be a normal occurrence and of little consequence. However, if it had become a chronic problem, a secondary infection or an inadequate drainage angle would have been suspected and investigated as appropriate.

Ideally, follow up radiographs should have been performed to monitor the affected area, however this was not carried out due to the positive clinical progress made by the patient.

The positive outcome achieved in this case is typical for surgical removal of paranasal sinus cysts provided the cyst lining is adequately debrided and appropriate drainage through a fenestration is achieved, as was the case with this horse.

**SUMMARY:**

An 18 month old Thoroughbred colt was diagnosed with a paranasal sinus cyst, involving the left maxillary and frontal sinuses. The horse presented with a unilateral left sided mucopurulent nasal discharge, facial deformity and difficulty breathing. The diagnosis was based on the history, clinical signs, upper airway endoscopy, radiographs of the paranasal sinuses, centesis of the left maxillary sinus and ultimately surgical exploration and histopathology of the lesion. A frontonasal flap was used to explore the sinuses and remove the cyst. The horse required a tracheostomy tube to be placed post surgery to ensure an adequate airway until the packing was removed. Broad spectrum antibiotic coverage was instituted post surgery to decrease incisional infection. Eight months post surgery the facial distortion had resolved, as had the majority of the septal deviation. Nasal discharge resolved and the horse has shown no residual signs of the presence of the paranasal sinus cyst.

## Endnotes:

- a. Pentax 1 meter videoendoscope endoscope, Olympus, Center Valley, PA
- b. Detomidine Hydrochloride, Dormosedan, Pfizer Animal Health, NY
- c. Butorphanol Tartate, Torbugesic, Fort Dodge, IA.
- d. Haussman gag, Jupiter Vet Products, Cedar Key Fl.
- e. Digital x ray machine, Eklin Mark III, Sound-Eklin, Carlsbad, Ca
- f. 14 gauge 5 1/2 inch Abbocath-T, Hospira, Inc, Lake Forest, IL.
- g. Tetanus Toxoid, Tetgaurd, Boehringer Ingelheim, St Joseph. MO
- h. Penicillin G Procaine, Phoenix pharmaceuticals, MO
- i. Gentamicin sulfate solution, Sparhawk Laboratories Inc, KY
- j. Phenylbutazone injection 20%, Phoenix Pharmaceutical, Inc, St Joseph, MO.
- k. Xylazine, Tranqved. Vedco, St Joseph, MO
- l. Diazepam, Hospira, Inc, Lake Forest, IL.
- m. Ketamine Hydrochloride, Ketaset, Fort Dodge Animal Health, Iowa, 50501
- n. Endotracheal tube-Jorgensen Laboratories, 1450 Van Buren Ave, Loveland, CO
- o. Isoflurane, Abbot Animal Health, Chicago, IL
- p. Lactated Ringers Solution, Baxter Healthcare Corporation, IL.
- q. 18 gauge surgical wire, IMEX Veterinary Products, Longview, TX.
- r. 2-0 Poliglecaprone 25, Monocryl, Ethicon, Johnson and Johnson, New Jersey.
- s. Precise Visa Skin Stapler, 3M Health Care. St Paul. MN.
- t. Adhesive tape, Microfoam 3 inch, 3M Health Care, St Paul, MN
- u. Tracheal tube, Jorgensen Laboratories, Loveland, CO.
- v. Phenybutazone paste, Vedco, St joseph, MO

- w. Sulfamethaxazole and trimethoprim tablets 800 mg/160mg, Amneal Pharmaceuticals, NY

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