**Key Points**

- Familiarity with the 3-D structural anatomy of the paranasal sinuses greatly facilitates surgical planning and surgery in a field often distorted and obscured by the presence of a mass and fluid accumulation
- Computed tomography is the best technique available for comprehensive paranasal sinus imaging and therapeutic planning
- Access to the ventral conchal sinus and rostral maxillary sinus is critical in performing a complete sinoscopic examination

The equine head has 6 paired paranasal sinuses (frontal, maxillary, dorsal conchal, ventral conchal, middle conchal/ethmoidal, and sphenopalatine) and all of these spaces communicate with each other and the nasal passage either directly or indirectly. A thorough understanding of the 3-D structural relationships will improve one’s ability to interpret imaging studies and plan the best approach to the sinuses. It is imperative to know what, and where, normal is for the sinuses, as often during surgery the visual field is one of accumulated fluid (e.g. blood, purulent material), and very abnormal architecture (e.g. presence of a mass). Imaging of the paranasal sinuses is critical to making a diagnosis and planning surgery. Radiography and computed tomography (CT) are the mainstays of sinus imaging, with rhinoscopy/sinoscopy very useful, and nuclear scintigraphy and magnetic resonance imaging (MRI) far less commonly employed.

**Sinus anatomy**

The combined conchofrontal and the rostral and caudal maxillary sinuses (RMS, CMS) are familiar and their anatomical arrangements and communications are readily understood. Topographical surgical anatomy to allow safe access to these sinuses is also relatively easy to follow and is well described in numerous texts. The maxillary sinus is partitioned into rostral and caudal regions by a variably located bony septum that extends obliquely mediocaudodorsad from the lateral wall of the maxilla. Commonly, the septum lies about 5 cm caudal to the rostral end of the facial crest and passes over the roots of the 1st and/or 2nd molars (maxillary 09, 10). The lateral portion of the septum is often identified radiographically as the most prominent bony septum arising over the 10 tooth. The septum blends dorsomedially into the bulla of the ventral conchal sinus (VCS). The CMS extends caudally, ventromedial to the bony orbit, to a vertical plane through the midpoint of the orbit. Trauma to the medial orbital wall communicates directly with the caudal maxillary sinus. The CMS has direct communication with the sphenopalatine sinus and the middle conchal (ethmoidal) sinus. The nasolacrimal duct runs along a line from the medial canthus of the eye toward the nasoincissive notch, slightly dorsal to the infraorbital foramen. This structure is preferably avoided when performing trephination or sinusotomy.

**Ventral conchal sinus (VCS), middle conchal sinus, and nasal cavity communications:**

The VCS lies medial (axial) to the maxillary sinuses, on the medial side of the infraorbital canal. The bulla of the VCS is its cartilaginous caudodorsal extension, and this bulbous, balloon-looking structure is seen via sinoscopy or sinusotomy in normal horses. The bulla is continuous
with the maxillary sinus septum. The VCS communicates with the RMS through the fissure-like conchomaxillary opening, which lies immediately dorsal to the infraorbital canal. The VCS can accumulate purulent exudate and this may be a reason for non-responsive chronic sinusitis. The ventral conchal bulla (VCB) dorsal wall is fenestrated to access the VCS and RMS. The middle conchal sinus is traditionally known as the greater ethmoturbinate. It is seen on nasal endoscopy and is the largest, bulbous structure in the ethmoid turbinates (can be mistaken for an ethmoid hematoma). The middle conchal sinus usually communicates with the CMS. Between the rostral edge of the frontomaxillary opening and the VCB a compressed passageway allows drainage from the CMS and RMS (independently or combined) through the nasomaxillary (sinonasal) opening into the middle nasal meatus of the nasal cavity. Physiological drainage from the sinuses is an active process.

Where is the sphenopalatine sinus?: The contiguous sphenoid and palatine sinuses lie ventromedial to the ethmoid labyrinth and extend caudally, beneath the cranium. The sinus communicates freely with the CMS. The entrance to the sinus is best seen via a maxillary sinusotomy or CMS trephined portal by looking caudomedially and dorsal to the infraorbital canal. The depths of the sphenopalatine sinus are typically beyond the reach of fingers so a sponge forcep, bronchoesophageal forcep, or other long handled instrument is useful for extracting masses from that area (e.g. ethmoid hematoma). Access via a conchofrontal sinusotomy or trephined portal is improved by removing the caudomedial border of the frontomaxillary opening; however, avoid damaging the extremely vascular ethmoid labyrinth.

How does patient age and dentition affect paranasal sinus anatomy?: The volume of the paranasal sinuses is directly related to the age of the horse, reflecting the expansion of the skull bones as the horse matures, and the development, eruption and migration of the maxillary cheek teeth. In the young horse, 4-6 years of age, the maxillary sinuses are occupied extensively by the reserve crowns of the last four cheek teeth (08 to 11). The tooth apices are contiguous with the vertical plate of bone supporting the infraorbital canal. This makes their individual identification extremely difficult when visualized through a sinusotomy or via sinoscopy and drastically limits any manipulations in the maxillary sinuses. For example, inspissated exudate in the VCS can be removed via a conchofrontal or maxillary sinus approach. For horses less than 5-6 years of age a conchofrontal approach is recommended to allow easier access to the VCS via penetration of the ventral conchal bulla. In older horses a maxillary approach becomes feasible as tooth roots retreat from the sinus and expose the infraorbital plate, although the conchofrontal approach is still often preferred (see later). Suffice it to say that there is variation between anatomical texts and between horses in relation to age-dependent tooth root locations in the maxillary sinuses. The 09, 10 and 11 teeth (first to third molars) have their apices consistently projecting into the maxillary sinuses, and in some horses the 08 tooth is also associated. The 09 is uniformly in the rostral maxillary sinus and the 11 is uniformly in the caudal maxillary sinus. In preparation for repelling a cheek tooth via trephination or sinusotomy it is standard practice and strongly recommended to use radiography to confirm the correct tooth roots will be struck. Because of variations in tooth position and size, related to age, the most anatomically correct siting of trephine portals for the maxillary sinuses has been studied.¹

Sinus imaging

Radiography: Radiography remains the most common and practical technique for imaging paranasal sinuses and quite often the information obtained allows ready planning of the next step, be it conservative or surgical. A good understanding of radiographic anatomy allows
confident assessment of locations of masses and fluid filled cavities. A recent report focused on the ability of clinicians to identify the VCB on radiographs of normal heads. The VCB was correctly identified in 70% of lateral radiographs, 45% of oblique projections and 17% of dorsoventral projections, with clinicians more likely to be correct when they were confident they could see the VCB wall. It was noted that the diseased VCB is likely to be thick-walled or outlined by fluid filling its space and so would be more easily identified, if normal anatomy is known beforehand. Radiographic assessment of the sphenopalatine sinus remains unreliable at best, due to superimposition of structures. Digital radiography, intraoral and open mouth views, have improved our ability to evaluate dental tissues, and the radiographic signs of apical infections, and consequent secondary sinusitis, have been recently described. Radiography and scintigraphy are highly complementary, increasing the likelihood of an accurate diagnosis than when either is performed alone. Radiographic guidance is indispensable for extraction of teeth by repulsion technique.

**Nuclear scintigraphy:** Bone scanning the head is often a neglected consideration when CT is an option. However, particularly if CT is not available, nuclear scintigraphy is very helpful in confirming dental-related sinusitis suspected on radiographs. Compared to CT and MR, scintigraphy has the advantages of being relative economical and is performed on the standing horse. It should not be forgotten as a useful imaging tool.

**Computed tomography:** CT is considered the state of the art imaging technique for the paranasal sinuses and its utility in determining presence of sinus disease and exactly what areas are involved is well established. In particular the identification of bilateral disease and smaller lesions, and disease of the sphenopalatine, ventral conchal and middle conchal sinuses are readily determined by CT. Sinus pathology secondary to dental disease is also often clarified and confirmed by CT. A recent report of the utility of CT for the treatment planning and management of progressive ethmoid hematoma (PEH) concluded that CT provided new diagnostic information for 10/16 horses studied, including 5/16 horses having bilateral disease not previously detected. Evaluation of the PEH’s proximity to the cribriform plate, and the integrity of the plate, was possible on sagittal and 3-D reconstructions, and knowing this information before treatment will help reduce the risk of severe complications secondary to cribriform plate compromise. The authors recommended CT for patients in which PEH cannot be seen via rhinoscopy, where sinus or multifocal disease is suspected, and when treatment has been unsuccessful. CT characteristics of sinonasal neoplasia and apical dental disease with secondary sinusitis have also been reported. The use of CT for imaging of the PNS is only going to increase as more CT facilities that can image a standing horse become available.

**Magnetic resonance imaging:** Despite the excellent tissue contrast and greater ability to determine disease pathogenesis compared to CT, MR remains a very infrequent imaging modality for PNS disease in the horse. This is due to the increased costs of the imaging technique and that little clinical advantage is yet realized from MR over CT, for assessment of PNS disease. For now, it is anticipated MR will continue to be the optimal imaging choice for brain pathology.

**Rhinoscopy/sinoscopy:** Direct visualization of the nasal passages and PNS is always informative. A flexible videoendoscope offers the most versatility in exploring the intricate sinuses and this is typically via a trephined portal. Alternative techniques include widening the nasomaxillary opening using balloon sinuplasty and a transnasal laser-assisted approach through the dorsal conchal sinus wall. Studies have looked at the best approach to the VCS and RMS for sinoscopic examination and concluded a conchofrontal portal with fenestration of the VCB.
provided reliable access to the RMS and VCS in most horses.\textsuperscript{11} If the VCB was not visible via the conchofrontal portal, a second portal in the CMS can be created to see the VCB and fenestrate it. Sinoscopy can often facilitate an effective treatment procedure of the diagnosed sinus disease through the same portal or an additional one.\textsuperscript{12} Interestingly, sinoscopy is not reliable in identifying apical dental disease as findings are often non-specific\textsuperscript{12,13}, and oral exam, radiographs and CT are necessary to confirm disease and the affected tooth/teeth.

Despite access to excellent imaging modalities, paranasal sinus disease can remain challenging to treat. It is anticipated that a trend towards routine use of CT will occur with an increase in standing CT facilities - therapeutic planning will be more comprehensive and outcomes more successful as a result.