Use of a novel helical fan beam imaging system for computed tomography of the head and neck in sedated standing horses: 120 cases (2019–2020)

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OBJECTIVE
To evaluate the diagnostic capabilities of a novel helical fan beam CT system used for imaging of horses with clinical problems of the head and neck.

ANIMALS
120 horses.

PROCEDURES
Medical records were reviewed of horses presented for CT of the head or neck at 2 university hospitals. The following data were recorded: age, sex, breed, presenting complaint, sedation used for imaging, scanning time, procedure time, other diagnostic imaging methods performed, imaging diagnosis, clinical diagnosis, and complications during imaging.

RESULTS
Quarter Horses and Warmbloods were the most common breeds, and the most common complaint was nasal discharge. The head (101/120 [84%] horses) was scanned most frequently, and the most common diagnoses were primary dental disease and a space-occupying lesion of the paranasal sinuses. Nuchal bursitis was the most common imaging diagnosis in the neck region. Procedure time ranged from 20 to 45 minutes with a scanning time of 30 to 40 seconds. No complications with horse sedation occurred, and horses tolerated scanning well. An imaging diagnosis was more frequently achieved with CT (109/120 [91%] horses) than with planar digital radiography (23/61 [38%] horses).

CLINICAL RELEVANCE
The helical fan beam CT system had fast scanning times and could be used safely for routine imaging of the teeth and sinuses in horses. The caudal extent of scanning in the neck region was limited by the shape of the horse’s neck and thorax.
Materials and Methods

Horses

Equine patients with a complaint related to the head or neck region that were presented for CT imaging with the Equina system at the University of Wisconsin-Madison Morrie Waud Large Animal Hospital between January 2019 and December 2020 or at the University of Melbourne Equine Centre between January 2019 and June 2020 were included in the study. The following data were recorded for each horse: age, sex, breed, presenting complaint, sedation used for imaging, other diagnostic imaging procedures, imaging diagnosis, clinical diagnosis, scanning and procedure times, and complications during imaging. The location for diagnostic imaging was selected by the referring equine veterinarian, a board-certified equine dentist, or a board-certified equine surgeon on the basis of history and results of a thorough clinical examination of the patient. The location was classified as head, neck, or head and neck.

CT scanning procedure

The Equina scanner was a fixed, 24-slice, helical fan beam CT machine with a 240 V single-phase, 30 A, uninterruptable power supply. The gantry diameter was 75 cm, with a field of view of 75 cm. Imaging was performed with an exposure of 160 kVp and 8 mAs at 1 second for each 360° revolution; there were 24 detector rows with a variable helical pitch, typically 0.55. Slice acquisition rate was 36 slices/s with an image acquisition matrix of 1,024 X 1,024 and resolution at isocenter of 0.75 mm. Maximum scan distance for scanning of the head and neck was 100 cm at 2 cm/s. No scout images were required. Bone and soft tissue reconstruction algorithms were available. On the basis of principles that were as low as reasonably achievable, personnel with protective radiation shielding and dosimeters were allowed to stay in the room during scanning to optimize horse handling, as determined by the regional environmental health and safety office. Window width and level were adjusted as needed to optimize image evaluation.

Horses were sedated with either acepromazine (0.02 to 0.05 mg/kg, IM) about 30 minutes before scanning and a bolus of detomidine (0.01 to 0.02 mg/kg, IV) immediately before entering the CT room or a combination of acepromazine (0.02 to 0.03 mg/kg, IV) and detomidine (0.01 to 0.02 mg/kg, IV) just before entering the CT room. Butorphanol (0.01 to 0.03 mg/kg, IV) was added if deemed necessary by the clinician. Additional IV boluses of detomidine hydrochloride were administered during scanning if necessary. Cotton was placed in the ears of the horse as earplugs, a blinker hood was placed over the horse’s head, and room lighting was dimmed during scanning.

The gantry of the Equina system could be tilted from 0° to 90° to allow for horizontal or vertical scanning. For scanning of the head and neck, the CT gantry was raised above the floor and rotated into a vertical position for horizontal scanning (Figure 1).

Figure 1—Photographs of the setup used for imaging of the head and neck region in a horse with a novel helical fan beam CT system. The gantry is raised from the floor and rotated into a vertical position for horizontal scanning (A). A sedated horse stands in the stocks with its head on a headrest (B). The gantry is then advanced caudally over the location of interest, and scanning is performed in a rostral direction.

After being sedated, the horse was walked into stocks that included a cushioned headrest. The gantry was mechanically raised to the appropriate height so that the horse’s head was comfortably resting on the head support. The gantry was then advanced caudally over the head and neck as needed to image the desired location. Scanning was then performed in a rostral direction. Scans were quickly reviewed by a board-certified radiologist or board-certified equine surgeon to determine whether they were of diagnostic quality, and scanning was repeated if any movement or artifacts were seen. Once scanning was completed, the horse was returned to a hospital stall for recovery.

If a contrast study was requested, a precontrast scan was performed first. Then, 350 to 400 mL of iohexol (240 mg of iodine/mL; Omnipaque) was infused IV slowly by manual injection through a catheter. Scanning was performed 1.5 to 3 minutes after contrast injection.

For each horse, the total number of scans and location of interest were recorded. Diagnostic-quality scans were evaluated by a board-certified veterinary radiologist using imaging viewing software to perform multiplanar reconstructions (Intellispace; Koninklijke Philips NV).

Radiography, ultrasonography, and videoendoscopy

Digital radiographs of the location of interest were acquired at the referral institutions in a subset of horses, as deemed appropriate by the attending clinician. A standard approach for radiographic examination (Varex Imaging with Canon film or Toshiba Model DS-FB with Fuji film) of the skull was used, incorporating techniques to minimize superimposition of skull structures. The affected and nonaffected sides of the patient were imaged for comparison. A minimum of 2 views of each dental quadrant were
obtained. The maxillary teeth were imaged in an open-mouth fashion with a dorsolateral-ventrolateral oblique view obtained at 60° in a right or left projection depending on the quadrant of interest. The mandibular teeth were imaged in an open-mouth fashion with a ventrolateral-dorsolateral oblique view obtained at 45° in a left or right projection depending on the quadrant of interest. Imaging of the nasal passages and paranasal sinuses involved lateral, dorsoventral, and distracted-mandible dorsoventral views. Oblique projections of the teeth and paranasal sinuses were obtained at multiple angles and intraoral views were obtained if appropriate for the presenting complaint.

If a soft tissue injury was evident on the CT images, an ultrasonographic examination (Logiq E vet machine; GE Healthcare; MyLab 70XVision; Esaote SpA) was performed to obtain additional diagnostic information, if possible. The examination was performed by a board-certified veterinary radiologist, board-certified equine dentist, or board-certified equine surgeon and used a standard approach with both longitudinal and transverse images obtained.

Oral examination with an equine dental speculum (Alumispec; Veterinary Dental Products) and large animal videoendoscope (Karl Storz) were performed as appropriate to confirm CT findings regarding dental disease and disease of the nasal and paranasal sinuses or guttural pouch. All images were evaluated by a board-certified veterinary radiologist or board-certified equine dentist, who assigned an imaging diagnosis. A board-certified equine dentist performed the oral examination and videoendoscopy. If necessary, sedation was obtained for these examinations with a combination of detomidine (0.01 to 0.02 mg/kg, IV) and butorphanol (0.01 to 0.03 mg/kg, IV).

Data analysis
Descriptive statistics (median, mean, range, and percentages) were generated with a commercially available spreadsheet program (Excel; Microsoft Corp). A clinical diagnosis was assigned on the basis of all findings, including results of clinical and oral examinations and all diagnostic imaging. For each imaging method, the percentage of cases for which the imaging diagnosis agreed with the clinical diagnosis, the percentage of cases for which the imaging diagnosis disagreed with the clinical diagnosis, and the percentage of cases for which an imaging diagnosis could not be made were determined. Agreement between radiographic and CT diagnoses was also evaluated.

Results
A total of 120 horses underwent standing CT scanning of the head and neck region during the study period. Breeds represented included Quarter Horse (n = 27), Warmblood (24), Thoroughbred (17), Paint Horse (10), Tennessee Walking Horse (6), Belgian (5), Standardbred (4), Arabian (3), Percheron (3), Saddlebred (3), Clydesdale (2), Lipizzaner (2), Welsh Pony (2), Morgan (2), Mustang (2), and Icelandic Horse, Appaloosa, Missouri Fox Trotter, Haflinger, Hackney Pony, Suffolk, Gypsy Vanner, and Friesian (1 each). There were 70 geldings, 47 mares, and 3 stallions. Mean age was 12.5 years (range, 6 months to 30 years).

Horses were presented for the following complaints: unilateral or bilateral nasal discharge (n = 41), facial or head swelling (11), epistaxis (10), draining tract (10), ataxia (10), problems with mastication or opening the mouth (9), head trauma (7), periorbital swelling (5), neck swelling or stiffness (5), pain or sensitivity of the poll (4), headshaking (4), retained tooth root (2), and reduced unilateral nasal airflow (2).

CT imaging
Most (110/120 [92%]) horses were sedated with a combination of acepromazine and detomidine IV or IM. In 5 (4%) horses, butorphanol was added to this combination. Five (4%) other horses were sedated with detomidine and butorphanol.

A total of 179 scans were acquired. The head was the location of interest in most (99/120 [83%]) horses. The head and neck was the location of interest in 11 (9%) horses, and the neck was the location of interest in 10 (8%) horses. Procedure times ranged from approximately 20 to 45 minutes with scanning times of 30 to 45 seconds for each location. Procedure time was approximately 45 to 60 minutes if a contrast study was performed. Diagnostic-quality scans were obtained in all cases. Median number of scans was 1 scan/case (mean, 1.5 scans/case; range, 1 to 3 scans/case). Repeated scanning was needed in 57 of the 120 (48%) horses, most often because of movement or artifacts. Repeated scanning was necessary for 42 of 99 (42%) head scans, 7 of 11 (64%) head and neck scans, and 8 of 10 (80%) neck scans. Procedure times were slightly longer if scans were repeated. There were minimal complications encountered during the scanning procedure. One horse that was presented with ataxia with a suspected head or neck problem went down in the stocks during scanning. Once down, the horse was heavily sedated and then removed from the stocks. The horse was uninjured and stood up after the sedation wore off and walked back to the stall. A small number of horses were resistant to entering the stocks initially, but this was resolved with additional sedation. No complications with horse sedation or contrast administration were identified.

CT imaging and clinical diagnosis
A space-occupying lesion in the nasal passage or paranasal sinuses was the clinical diagnosis in 26 of 120 horses. The space-occupying lesion could be differentiated through clinical, endoscopic, and histopathologic examination as a tumor (n = 9), ethmoid hematoma (5), poly (2), cyst (9), or abscess (1). Primary dental disease, with or without secondary sinusitis, was the second most common clinical diagnosis (n = 23; Figure 2). Other clinical diagnoses were fractures (n = 10), periorbital tumor or abscess (7), temporohyoid osteoarthropathy (6), temporomandibular joint disease (6), sequestrum (5), primary sinusitis (5), nuchal bursitis (4; Figure 3), myositis ossificans or hematoma (4), dentoingent cyst (3; Figure 4), dental tumor (3),
guttural pouch empyema (2), C2-C3 subluxation (1), parotid sialocele (1), choanal atresia (1), tumor in the cranium (1), and osseous mandibular cyst (1; Table 1). In 11 cases, no clinical diagnosis was made after examination and diagnostic imaging. In 5 of these 11 cases, the head and neck was scanned; in 4, the head was scanned; and in 2, the neck was scanned. Six of these 11 horses had a neurologic presenting complaint.

Contrast medium was used in 4 cases during CT scanning. In 2 cases, it was used for identification of nuchal bursitis; in 1 case, it was used for identification of a sialocele; and in the remaining case (a horse with a neurologic presenting complaint), the diagnosis remained open.

**Agreement between imaging and clinical diagnoses**

CT and clinical diagnoses were made in 109 of the 120 (91%) horses (Table 1). A clinical diagnosis was made in 95 of the 99 (96%) horses that underwent scanning of the head, 6 of the 11 (55%) horses that underwent scanning of the head and neck, and 8 of the 10 (80%) horses that underwent scanning of the neck.

In all 109 cases, the imaging diagnosis was confirmed by means of oral examination, videoendoscopy, surgery, or histopathologic examination.

Radiography was performed in 61 horses, and a radiographic diagnosis was made in 23 of the 61 (38%). Ultrasonography was performed in 12 horses, and an ultrasonographic diagnosis was made in 7 (58%). Videoendoscopy was performed in 37 horses, and an endoscopic diagnosis was made in 9 (24%).

The CT and radiographic diagnoses agreed for 14 of the 61 horses for which both CT and radiography were performed (Table 2). For 9 horses, the radiographic diagnosis disagreed with the CT diagnosis. For 7 of these 9 horses, the clinical diagnosis was primary dental disease, and CT imaging revealed a more advanced stage of the condition.

**Figure 2**—Dorsal (A) and transverse (B) multiplanar reconstructed CT images of a 7-year-old Quarter Horse with diffuse right rostral and caudal maxillary paranasal sinusitis (red arrows). Fluid secondary to lysis of the periapical alveolar bone of the maxillary molar tooth (tooth 111), likely due to tooth root infection (yellow arrow), can be seen.

**Figure 3**—Lateral radiographic (A) and sagittal multiplanar reconstructed CT (B) images of a horse with a draining tract in the neck. A catheter has been inserted into the draining tract and iohexol has been injected. On the radiographic image, the caudal margin of the occipital bone has a mild amount of undulant osseous proliferation (arrow), and regions of mild decreased opacity along the caudal occipital bone are seen. Findings are consistent with osteomyelitis of the occipital bone associated with chronic nuchal bursitis and a draining tract. On the CT images, marked permeative lysis throughout the caudal aspect of the occipital bone with the catheter extending through the region of the draining tract to the level of the cerebellum (arrow) can be seen. The extent of the draining tract was more evident on the CT image than on the radiographic image.

**Figure 4**—Rostrocaudal (A) and lateral (B) radiographic images of the left zygomatic process and a transverse multiplanar reconstructed CT image (C) of the head of a horse. On the radiographic images, a tooth-like structure is superimposed over the calvarium at the region of the base of the ear (red arrow). This structure is consistent with a dentigerous cyst. On the CT images, a large tooth-like structure can be seen in the zygomatic process of the left temporal bone (red arrow). There is focal loss of bone between the tooth-like structure and the cerebrum (yellow arrow), which was not observed on radiographic images. This region is also intimately associated with the temporomandibular joint. Findings were consistent with a dentigerous cyst with communication into the cerebrum.
Table 1—Results of diagnostic imaging for 120 horses presented for CT scanning of the head and neck region.

<table>
<thead>
<tr>
<th>Clinical diagnosis</th>
<th>No. of cases</th>
<th>Radiographic imaging</th>
<th>Ultrasonographic imaging</th>
<th>Endoscopic imaging</th>
<th>CT imaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space-occupying lesion(^a)</td>
<td>26</td>
<td>5/9</td>
<td>1/1</td>
<td>3/15</td>
<td>26/26</td>
</tr>
<tr>
<td>Primary dental disease(^b)</td>
<td>23</td>
<td>7/15</td>
<td>0/0</td>
<td>0/9</td>
<td>23/23</td>
</tr>
<tr>
<td>Fracture</td>
<td>7</td>
<td>1/2</td>
<td>0/1</td>
<td>0/0</td>
<td>7/7</td>
</tr>
<tr>
<td>Periorbital tumor or abscess</td>
<td>7</td>
<td>0/1</td>
<td>0/1</td>
<td>0/0</td>
<td>7/7</td>
</tr>
<tr>
<td>Temporomandibular joint disease</td>
<td>6</td>
<td>2/3</td>
<td>2/2</td>
<td>0/0</td>
<td>6/6</td>
</tr>
<tr>
<td>Sequestrum</td>
<td>5</td>
<td>0/3</td>
<td>0/0</td>
<td>0/1</td>
<td>5/5</td>
</tr>
<tr>
<td>Primary sinusitis</td>
<td>5</td>
<td>0/4</td>
<td>0/0</td>
<td>0/3</td>
<td>5/5</td>
</tr>
<tr>
<td>Temporohyoid osteoarthopathy</td>
<td>3</td>
<td>0/3</td>
<td>1/1</td>
<td>3/3</td>
<td></td>
</tr>
<tr>
<td>Dentigerous cyst</td>
<td>3</td>
<td>3/3</td>
<td>0/0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dental tumor</td>
<td>3</td>
<td>2/2</td>
<td>0/0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle-related disease(^c)</td>
<td>2</td>
<td>0/0</td>
<td>2/2</td>
<td>0/1</td>
<td>2/2</td>
</tr>
<tr>
<td>Guttural pouch empyema</td>
<td>2</td>
<td>0/1</td>
<td>0/0</td>
<td>2/2</td>
<td></td>
</tr>
<tr>
<td>Parotid sialocele</td>
<td>1</td>
<td>0/0</td>
<td>1/1</td>
<td>0/0</td>
<td>1/1</td>
</tr>
<tr>
<td>Choanal atresia (unilateral)</td>
<td>1</td>
<td>0/0</td>
<td>0/0</td>
<td>1/1</td>
<td>1/1</td>
</tr>
<tr>
<td>Osseous cyst (mandible)</td>
<td>1</td>
<td>0/1</td>
<td>0/0</td>
<td>0/0</td>
<td>1/1</td>
</tr>
<tr>
<td>Open diagnosis</td>
<td>4</td>
<td>0/0</td>
<td>0/0</td>
<td>1/1</td>
<td>4/4</td>
</tr>
<tr>
<td>Head and neck region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporohyoid osteoarthopathy</td>
<td>3</td>
<td>1/2</td>
<td>0/0</td>
<td>1/1</td>
<td>3/3</td>
</tr>
<tr>
<td>Tumor invading cranium</td>
<td>1</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
<td>1/1</td>
</tr>
<tr>
<td>Fracture</td>
<td>1</td>
<td>1/1</td>
<td>0/0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle-related disease(^c)</td>
<td>1</td>
<td>0/0</td>
<td>0/0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open diagnosis</td>
<td>5</td>
<td>2/2</td>
<td>0/0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuchal bursitis</td>
<td>4</td>
<td>1/4</td>
<td>1/3</td>
<td>0/0</td>
<td>4/4</td>
</tr>
<tr>
<td>Fracture</td>
<td>2</td>
<td>0/2</td>
<td>0/0</td>
<td>0/0</td>
<td>2/2</td>
</tr>
<tr>
<td>C2-C3 subluxation</td>
<td>1</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
<td>1/1</td>
</tr>
<tr>
<td>Muscle-related disease(^c)</td>
<td>1</td>
<td>0/1</td>
<td>0/0</td>
<td>0/0</td>
<td>1/1</td>
</tr>
<tr>
<td>Open diagnosis</td>
<td>2</td>
<td>2/2</td>
<td>0/0</td>
<td></td>
<td>2/2</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>23/61</td>
<td>7/12</td>
<td>9/37</td>
<td>109/120</td>
</tr>
</tbody>
</table>

For all horses, a clinical diagnosis was assigned on the basis of all diagnostic findings, including results of clinical and oral examinations and diagnostic imaging. For each imaging method, data represent number of horses in which the diagnosis was made/number of horses that underwent imaging. Radiography, ultrasonography, and endoscopy were not performed in all horses.

\(^a\)Space-occupying lesion of the head, nasal passage, or paranasal sinuses (ie, tumor, abscess, polyp, cyst, or ethmoid hematoma).

\(^b\)With or without secondary sinusitis.

\(^c\)Myositis ossificans or hematoma.

Table 2—Agreement between radiographic and CT diagnoses for 61 horses that underwent both radiography of the head and neck and CT imaging with a novel helical fan beam CT system.

<table>
<thead>
<tr>
<th>Location of interest</th>
<th>Underwent radiography</th>
<th>Agreement with CT diagnosis</th>
<th>Disagreement with CT diagnosis</th>
<th>No radiographic diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>47</td>
<td>11</td>
<td>9</td>
<td>27</td>
</tr>
<tr>
<td>Head and neck</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Neck</td>
<td>9</td>
<td>1</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
<td>14</td>
<td>9</td>
<td>38</td>
</tr>
</tbody>
</table>

Data represent number of horses.

Discussion

We found that the Equina system could be used to scan the head and proximal neck region in sedated standing horses and provided good-quality diagnostic CT images. We scanned 120 horses without clinically important complications and achieved CT imaging and clinical diagnoses in 109 (91%). CT imaging was more likely to result in an imaging diagnosis than was planar radiography.

Diseases of the nasal passage or paranasal sinuses (26/120 horses) and primary dental disease (23/120 horses) were the most common diagnoses for horses that underwent scanning of the head. Results of radiography and CT imaging for horses with these 2 conditions often did not agree with each other, or CT resulted in an imaging diagnosis when radiography did not. In horses with diseases of the nasal passage or paranasal sinuses, CT imaging often indicated, on the basis of radiographic images,
that more anatomic structures were involved than expected, and in horses with primary dental disease, CT imaging identified more advanced lesions or additional lesions. It has previously been shown that CT imaging is advantageous in horses with dental disorders, especially horses with cheek teeth infections. Other imaging methods such as nuclear scintigraphy and MRI have been used to investigate suspected dental disease but are time-consuming, have poor image resolution, and potentially require general anesthesia. The paranasal sinus system is anatomically complex and challenging to image. In addition, the anatomic boundaries of sinus structures are obscured on planar radiographic images in horses with sinusitis.

CT imaging has also proven beneficial for imaging fractures of the skull and the sinonasal region of the head. Traumatic head injuries are common in horses. Radiography underestimates the extent and complexity of fractures as well as the involvement of adjacent soft tissue. Differentiation of soft tissue structures in the head and neck is possible with the Equina system, as with other helical CT systems. However, if high detail is needed, MRI may be advantageous, even though it requires general anesthesia. Attenuation measurements might help to distinguish between some abnormal soft tissue structures and free fluid; however, there can be considerable subjective variation. Further research with both the Equina system and other helical CT machines relating to attenuation measurements is warranted.

Nuchal bursitis was the most common imaging diagnosis in the neck region for horses in the present report. This condition is relatively uncommon and mostly diagnosed by means of radiography and ultrasonography, although other imaging modalities may be useful in chronic cases. In most cases in the present report, no radiographic or ultrasonographic diagnosis was obtained because patient examination could not reliably identify the anatomic location for diagnostic imaging. If a radiographic diagnosis was made, agreement with the CT diagnosis was excellent because these horses had more chronic changes on radiographs. In addition, CT imaging was able to provide more detail of the surrounding soft tissue and osseous structures.

Positioning of the horse and our sedation protocol were similar to those used for other CT studies involving standing evaluation of the head and neck. Most of the horses received an α2-adrenoceptor agonist as a sedative with or without acepromazine as a tranquilizer. Cotton earplugs, a blinker hood, and dimming of the room lights helped to keep horses calm during the procedure while horses were in the stocks with their heads resting on a headboard. Personnel wearing lead shielding and dosimeters were approved by the regional environmental health and safety office to remain in the room standing adjacent to the horse, allowing them to easily assess the horses’ behavior and take quick action to minimize risk of harm to horses or the CT machine. Scattered radiation can affect image quality and create artifacts. This is potentially important when imaging a complex structure, such as the head, when image detail is important, such as when imaging dental disease cases. Cone-beam volumetric imaging has high radiation scatter and increased artifact occurrence, and gas accumulation in the pulp cavity may not be detected. This can be clinically important in animals with endodontic abnormalities such as apical infections, and helical CT imaging may be more reliable in these cases. With the growing use of standing CT imaging of horses, thorough evaluation of occupational exposure is needed for the Equina system and other types of standing CT imaging systems.

Patient motion and incorrect positioning were the main reasons a scan was repeated in the present study. In this study, 1 to 3 scans were performed, with scan times of approximately 20 to 45 minutes. No scout images are needed with the Equina system, which helps reduce imaging times. Repeated scans were needed in 57 of the 120 (48%) horses and were more often required if the scanned location was the neck region (6/10 [80%]) or head and neck region (7/11 [64%]), compared with the head cases (42/99 [42%]). This was not surprising, because scans of the head and neck together have a longer acquisition time. The caudal-to-rostral scanning process could not be stopped halfway if only the neck was the location of interest. New software has been developed that allows the scanning process to be stopped at any point, which will allow the anatomic region undergoing scanning to be minimized with an expected reduction in the risk of motion artifact. We did find that slight motion could obscure the detail of head structures easily, such that a repeated scan was more often needed when imaging the head and neck, compared with imaging the distal limbs.

IV and intra-arterial contrast enhancement techniques have been described for horses. The IV technique uses more contrast medium than the intra-arterial technique, because the contrast medium is diluted before reaching the location of interest, but the contrast enhancement obtained with the 2 techniques is similar. Contrast-enhanced CT scans provide additional imaging information, but the usefulness of contrast CT of the equine skull has been questioned. In the present study, iohexol was used in 4 horses, and the use of contrast CT for patients with seizures to screen for intracranial disease could be studied in the future. However, no patients with seizures have been scanned with the Equina system to date. The number of equine contrast studies described in the literature is low, and more research is needed on the utility of contrast CT for head and neck imaging, including standing myelography.

The caudal extent of the neck that can be imaged with the Equina CT scanner is influenced by the shape of the horse’s neck and thorax. A short neck, wide neck, or prominent thorax limited the caudal extent of scanning. For some horses of the present study, a scan as far caudally as the cranial part of the body of C5 was acquired, but the caudal limit for neck scans was the cranial part of the body of C4 in most horses. This means that diseases such as osteoarthritis of the caudal intervertebral joints cannot be imaged with this system in standing horses.
Further research is needed to investigate caudal cervical imaging with the Equina system of horses under general anesthesia. More precise measurements of neck dimensions of horses with various conformations would likely be helpful for CT planning.

There were several limitations to the present retrospective study. The location for scanning was selected on the basis of clinical signs and the lack of an imaging diagnosis with previous imaging prior to referral. Our results suggested that CT imaging has good diagnostic accuracy, in that the CT diagnosis was confirmed by additional clinical or surgical examinations of the location of interest in all 109 cases with a CT imaging diagnosis. However, the board-certified veterinary radiologist evaluating the cases was aware of the clinical presentation. Noblinding or independent viewing by other board-certified radiologist of the scans was performed, as is typically the case in clinical practice. Further investigations incorporating independent assessments to determine sensitivity and specificity of radiography and CT for diagnosis of common head and neck conditions would be helpful. In most cases, the presenting location of interest was also the location in which the imaging and clinical diagnoses were made. However, horses that underwent CT scanning of the neck were more likely to end up with an open imaging diagnosis or a clinical diagnosis in a different location. In the present study, 11 horses still had open imaging and clinical diagnoses after CT imaging. It would have been helpful to have determined a diagnosis for these cases.

In conclusion, the present study described routine use of a novel helical fan beam CT system for imaging of the head and neck in sedated standing horses. Rapid scanning times and subjective ease of use made this machine attractive for investigation of diseases of the head and neck. Personnel wearing protective radiation shielding were allowed to remain in the room with the horse during scanning, as approved by the regional environmental health and safety office, which facilitated safe handling of the patients. The diagnostic utility of obtaining an imaging diagnosis with CT scanning was high. Future research is needed to evaluate the use of contrast medium in standing horses and the clinical potential for routine use of this machine in horses with conditions involving the neck region.

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