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Computed Tomography of the Equine Head

by Sarah Powell

What is CT?

Radiography is based on the absorption of radiation in the form of x-rays as they pass through parts of the animal. Depending on the amount absorbed by a particular tissue (such as bone or soft tissue), a varying amount of x-rays will pass through the tissue and exit the body. During conventional x-ray imaging (plain radiography), the exiting x-rays interact with a detection device (x-ray film or digital plate) and provide a two-dimensional projection radiographic image of the tissues within the horse's body.

Although also based on the variable absorption of x-rays by different tissues, computed tomography (CT) imaging, also known as 'CAT scanning' (computerized axial tomography), provides a different form of imaging known as cross-sectional imaging. The origin of the word 'tomography' is from the Greek word 'tomos' meaning 'slice' or 'section' and 'graphe' meaning 'drawing'. A CT imaging system produces very high quality cross-sectional images or 'slices' of anatomy, like slicing a loaf of bread. The cross-sectional images can be manipulated or post processed in a number of ways to be used for a variety of diagnostic purposes in a diverse range of pathologic conditions **(Figure 1).**

With clear benefits over other imaging techniques when imaging complex anatomic areas, CT was first used by veterinary surgeons in the early 1980s, but the machines built for human patients didn't lend themselves well to use for horses. The modifications for use in equine patients were initially makeshift and cumbersome but this advanced imaging technique was to prove useful in a range of conditions and D. D. Barbee and his colleagues at Washington State University first published the technique in the 1986 Proceedings of the American Association of Equine Practitioners.

The progress of CT technology has been relentless and the result is a rapid turnover of CT machines in human hospitals. This has led to an abundance of equipment becoming available on the second-hand market, making the installation of a CT facility a viable prospect for larger equine veterinary hospitals. Techniques for a diverse range of equine orthopaedic and medical conditions, of both the head and distal limbs of adult horses and thorax and abdomen of foals, have been described over the last decade as CT affords us an unprecedented amount of information in complex conditions, which is unequalled by other means.

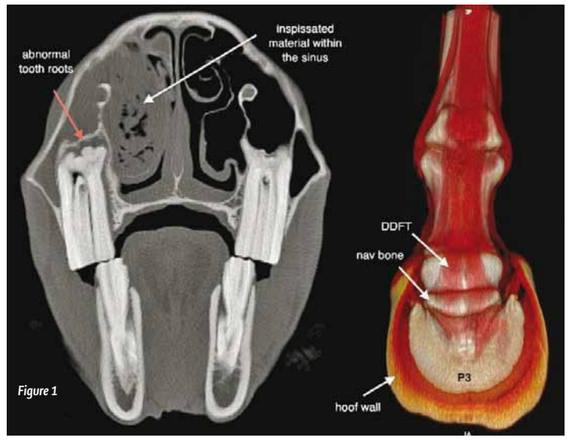

Figure 1

From head to toe! Two dimensional images (left) can be used to detect fluid in the sinuses and damage to the roots of the teeth. Alternatively the 'slices' can be post processed to form 3D images (right), which is useful in some orthopaedic conditions.

Until recently it was necessary to anaesthetise horses that required a computed tomographic scan of any area of the body. However, in 2006 the late Alastair Nelson designed and installed at Rainbow Equine Clinic the first CT system in the UK capable of scanning the equine head whilst the horse was standing, under sedation. The legacy that Alastair left is a dramatic increase in the number of equine CT scans being performed, as the cost to the client and the risk to the patient has been reduced. Four centres across the UK, including Rossdales Equine Diagnostic Centre, have installed versions of Alastair's standing system, with more planned for the future both in Europe and the USA.

How is a CT scan carried out?

Scanning horses under standing sedation is not a simple procedure and requires a team of veterinary support staff in addition to the veterinary radiologist. It takes time and patience to position the horses correctly, the horse must stand squarely and stable on all four limbs whilst under profound sedation **(Figure 2)**. The standing systems vary slightly but all require the horse's head to move slowly through the gantry whilst positioned on the human CT table **(Figure 3)**. This requires the horse to stand on a platform that is capable of moving without friction. The system at Rossdales utilises a platform attached to the human CT table, which moves along the floor in stainless steel runners via a system of air skates, inflated via a compressor system located adjacent to the scanning room.

Figure 2

A horse is positioned on the standing platform at Rossdales Equine Diagnostic Centre prior to undergoing a CT scan of the head. Achieving an optimal sedation level to enable the horse to accept the procedure, whilst not being too ataxic (loss of ability to co-ordinate muscles) to stand squarely on the inflatable platform, is critical to the success of the scan procedure.

Carrying out a scan with minimal risk of injury to both horse and humans requires handlers who are familiar with the system, experienced in sedation techniques and skilled at working with nervous horses. It is often the work of the nurses and imaging technicians during the positioning of the horse's limbs and securing the head in the gantry that leads to the completion of a successful CT scan. Sedation methods vary between centres but usually consist of a premedication with acepromazine followed by a combination of butorphanol and detomidine. The use of diazepam may enable extremely nervous horses to be scanned successfully. Horses that cannot safely be scanned under standing sedation can be anaesthetised and the images acquired with the horse recumbent on the modified general anaesthetic table.

Figure 3

The platform is connected to the human CT table, which moves through the gantry, pulling the horse through the bore of the CT machine as the x-ray tubes rotate around him. The sand bags over the neck weigh the patient down to ensure the horse's mandible is firmly in contact with the table, minimising patient movement during the scan.

What are the benefits of CT?

This rapid accumulation of accurate data is proving invaluable for vets working in many specialities but particularly for those dealing with head, dental and sinus pathology, where CT has proved extremely useful. A CT scan enables precise evaluation of the teeth and their relationships to the structures around them such as masses and fluid within the sinuses **(Figure 4)**, without the overlay of anatomy, which so often complicates and obscures plain radiographs. One of the advantages of CT images is the post processing capability, where images can be reformatted to view them in multiple orthogonal planes **(Figure 5)**, three dimensional reconstructions of bony structures and teeth **(Figure 6)** and even to reconstruct endoscopic views of the nasal passages, pharynx and larynx **(Figure 7)**. Post processing of images is extremely useful in the investigation of skull fractures and conditions of the guttural pouches and hyoid apparatus, the latter of which is implicated in the horse's senses of taste, hearing, and balance. This extra information leads to definitive diagnoses and more appropriate treatment and, in many cases the images serve to guide surgical treatment of a number of sinonasal conditions **(Figure 8)**.

CT will undoubtedly continue to establish its role as a diagnostic tool in equine veterinary imaging. The cost of the scan and risk of general anaesthesia (when necessary) is offset by the information the CT scan affords the clinician, which can be instrumental in arriving at a correct diagnosis, planning surgical or medical treatment and ensuring the best outcome for the case. As more CT scanners become available around the country these exquisite images may well become the gold standard of care in a number of equine diseases.

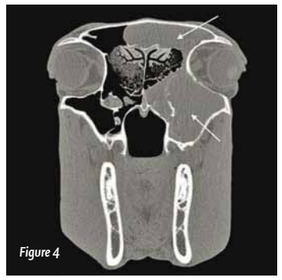

Figure 4

A single CT image or 'slice' through the head at the level of the eyes. Fluid can be seen filling the dental sinuses on the right side of the image (arrows). This horse was suffering from an ethmoid haematoma, which was removed under sedation following the CT scan.

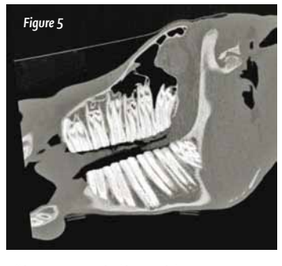

Figure 5

All images are acquired in an axial or transverse (horizontal) plane. The images can then be processed after the scan and reconstructed into orthogonal planes. Here, in a process called 'multiplanar reformatting' a sagittal (vertical) plane view of the cheek teeth has been created from the axial image data.

Figure 8

Rossdales Surgeon Richard Payne removing a mass from a horse's sinus. The CT images of this horse, which were acquired earlier that day, are displayed on the wall in the standing surgery suite to assist Richard during the procedure and ensure the mass is removed in its entirety.

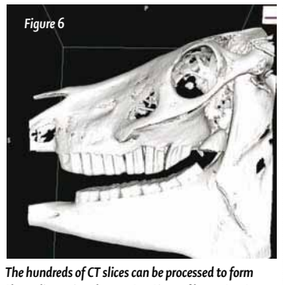

Figure 6

The hundreds of CT slices can be processed to form three-dimensional reconstructions of bony structures such as the skull seen here. These images are useful in the assessment of skull fractures, for example.

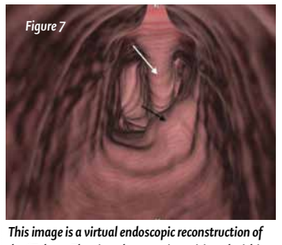

Figure 7

This image is a virtual endoscopic reconstruction of the CT data. The virtual camera is positioned within the nasopharynx looking rostrally towards the nasal passages and nasal septum (white arrow). A mass is present in the soft palate (black arrow), which was associated with a fracture of the hamulus (a small bony process on the base of the skull).

Vet Profile

Name: Sarah E. Powell
Qualifications: MA VetMB Assoc. (LA) ECVDI MRCVS
Biography: Sarah is a senior orthopaedic clinician at Rossdales Equine Diagnostic Centre, Newmarket where she heads the 3D imaging facility. Sarah has a particular interest in advanced imaging techniques, a subject on which she publishes and lectures regularly. Sarah provides an image reading service and MRI consultancy to a number of veterinary practices around the world. She has a special interest in the use of MRI to detect stress injuries in racehorses and has a number of collaborative equine clinical research projects in progress in both this area and in other aspects of equine CT and MRI.

Sarah is an associate of the European College of Veterinary Diagnostic Imaging.

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