Equine Veterinary Education

EQUINE VETERINARY EDUCATION
Equine vet. Educ. (2019) •• (••) ••-••
doi: 10.1111/eve.13125

Original Article

Intervertebral disc disease of the cervical and cranial thoracic vertebrae in equidae: eight cases

***S. Dyson**[*†], **V. Busoni**[‡] **and A. Salciccia**[‡]

[†]*Centre for Equine Studies, Animal Health Trust, Newmarket, Suffolk, UK ; and* [‡]*Equine Clinic, University of Liège, Liège, Belgium*

**Corresponding author email: sue.dyson@aol.com*

Keywords: ataxia; discospondylitis; forelimb lameness; horse; neck locking; neck stiffness

Summary

Intervertebral disc disease in the cervical and cranial thoracic vertebrae is unusual in horses and the majority of documented cases have been associated with infection and resulted in ataxia. The current retrospective study documents the clinical and imaging features, and outcome in eight Equidae with neck stiffness ± forelimb lameness (n = 3) or ataxia (n = 2) assessed during a 10-year period at two clinics. The Equidae (one donkey and seven horses) ranged in age from 1.5 to 12 years (median 5.5 years). The duration of clinical signs ranged from 1 to 6 months (median 1.5 months). The donkey had a depressed demeanour. All Equidae had reduced range of neck movement. The donkey and one horse showed mild and severe ataxia respectively. Two horses showed a propensity to stumble on each forelimb, one of which exhibited forelimb lameness on the lunge or ridden. Two additional horses showed lameness in hand. One horse experienced 'neck locking' during grazing. Radiological abnormalities were identified involving the intervertebral symphysis between the sixth cervical vertebra (C6) and C7 in four Equidae; in two horses the articulation between C7 and the first thoracic vertebra (T1) was involved. One horse had abnormalities of the intervertebral symphyses of both C7 and T1, and T1 and T2. In one horse the articulation between C2 and 3 was affected. The donkey was treated with a prolonged course of doxycycline and improved. An advanced dressage horse returned to full-function after surgical fusion of the affected intervertebral symphysis. Intervertebral disc disease is a rare cause of neck stiffness ± lameness or ataxia.

Introduction

Discospondylitis is an inflammatory condition involving the vertebral bodies adjacent to the intervertebral symphysis (Nomina Anatomica Veterinaria 2005) and their associated intervertebral disc. Discospondylitis in the cervical and cranial thoracic vertebral column is an unusual condition, to which there is only limited reference in the equine literature (Adams *et al*. 1985; Hillyer *et al*. 1996; Speltz *et al*. 2006; Sweers and Carsten 2006; Alward *et al*. 2007; Garcia *et al*. 2015). Most reports describe the condition in adult horses and clinical signs have included neck stiffness, neck pain, a stiff or short-stepping forelimb gait and forelimb lameness. Ataxia is also reported as a clinical sign, associated with protrusion of disc material into the vertebral canal (Foss *et al*. 1983; Nixon *et al*. 1984; Adams *et al*. 1985; Stadler *et al*. 1988; Furr *et al*. 1991; Hillyer *et al*. 1996; Colbourne *et al*. 1997; Sweers and Carsten 2006; Garcia *et al*. 2015). Infection has been recognised as the cause in the majority of horses (Foss *et al*. 1983; Nixon *et al*. 1984; Adams *et al*. 1985; Stadler *et al*. 1988; Furr *et al*. 1991; Hillyer *et al*. 1996; Colbourne *et al*. 1997; Sweers and Carsten 2006; Garcia *et al*. 2015) but attempts to identify the aetiological agent were largely unsuccessful. The aetiology of intervertebral disc disease in other reported cases remains unclear, although trauma has been reported (Adams *et al*. 1985; Speltz *et al*. 2006; Denoix 2007).

Previous surveys of 17 horses from 3 months to 19 years of age (Yovich *et al*. 1985) and 103 horses from birth to 23 years of age (Bollwein and Hanichen 1989), had indicated that the cervical intervertebral discs consist of fibrocartilage, with no nucleus pulposus. Age-related degenerative changes were identified, but even with severe disintegration of the discs, no related clinical signs had been recognised. However, a recent gross and histological study of the intervertebral discs of 33 Warmblood horses demonstrated that there was a nucleus pulposus and annulus fibrosus which were similar in structure to dogs and people, although the distinction between the regions was much less clear (Bergmann *et al*. 2018). Grade 4 and 5 degenerative changes (on a scale of 0–5) were found in 36% of horses in the segment between the fifth cervical (C5) and first thoracic (T1) vertebrae, which was a considerably higher frequency of occurrence than elsewhere in the vertebral column. It has been suggested that disc degeneration may increase intervertebral mobility, and associated dorsal bulging of the dorsal longitudinal ligament could potentially contribute to spinal nerve root compression at the entrance to the intervertebral foramen (K. Whitwell, personal communication, cited by Dyson 2011).

The purpose of this report was to describe the history, clinical and imaging features of intervertebral disc disease in eight Equidae, in six of which ataxia was not observed.

Materials and methods

Case records from the University of Liège and the Animal Health Trust (AHT) from 2008 to 2018 were interrogated to identify Equidae (D1 and H2–8, **Table 1**) with a diagnosis of cervical intervertebral disc disease. All animals underwent comprehensive static and dynamic physical examinations, repeated on several occasions. Horses 5–8 were evaluated moving on the lunge and ridden. Horse 6 underwent diagnostic analgesia of the lame forelimb (Bassage and Ross 2011). Ultrasound-guided (Nielsen *et al*. 2003) intra-articular

analgesia of the left articular process joint between the seventh cervical (C7) and T1 vertebrae was performed in Horse 7. Blood samples were collected for measurement of white blood cell count, fibrinogen and serum haptoglobin (D1), or serum amyloid A (H4) concentrations. Lateral–lateral radiographs of the cervical and cranial thoracic vertebrae were acquired (Butler *et al*. 2017). Images were interpreted by a Diplomate (V.B.) or an Associate (S.D.) of the European College of Veterinary Diagnostic Imaging.

Results

There were one donkey (D1, **Table 1**) and seven horses (H2–8), which ranged in age from 1.5 to 12 years (mean 6.3 years; median 5.5 years). There were five geldings, two stallions and one mare, used for general purpose riding (n = 2, including unaffiliated competition), dressage (n = 2), eventing (1), endurance (1) and driving (1); one horse was unbroken. Breeds included three Warmbloods and one each of Thoroughbred cross, Highland Pony, Akhal Téké and a pony. Height ranged from 142 to 167 cm (n = 4), Cases 5–8; mean 154.8 cm. Bodyweight ranged from 328 to 575 kg (median 480 kg, mean 455 kg).

Clinical features

The duration of clinical signs ranged from 1 to 6 months (mean 2.4 months, median 1.5 months). The donkey had a depressed demeanour and low head posture. All horses had a normal neck posture at rest, but when passive neck flexion was assessed using baited stretch exercises, flexion was limited. Neck muscle development was generally poor in five horses (H 3,4,5,7,8), but no focal muscle atrophy was observed. There was no patchy sweating, hyperaesthesia or allodynia, but Horse 5 showed a marked pain response when the caudal aspect of the left side of the neck was palpated when the horse exhibited neck 'locking'. All Equidae experienced difficulties in lowering the neck to graze, exhibiting a straddled stance with both forelimbs widely separated (D1, H2–4 and 6–8). Horse 3 would not eat from the ground and Horse 7 could not reach the ground to eat. Horse 5, after grazing for several minutes, developed neck 'locking': the neck became fixed in a lowered position, sometimes with the neck bent to the right (**Fig 1a**). He tended to cross the forelimbs while grazing, or had the left front fetlock knuckled forwards. The horse walked forwards with the neck fixed in a low position. This persisted for up to 10 minutes and would then resolve spontaneously.

When evaluated moving in hand in straight lines, five horses (H 2,5,6,7,8) had a stiff neck posture. When turned in small circle these horses, in addition to Horse 4, had reduced range of motion of the neck. Two Equidae showed mild (D1, grade 1 – forelimbs) and severe (H2, grade 3 – hindlimbs > forelimbs) ataxia respectively (using a 0–4 ataxia-grading scale [Reed 2003; Olsen *et al*. 2014]). No other animal showed evidence of ataxia or weakness. However, Horses 2 and 6 had a propensity to stumble on each forelimb. For Horse 6 this was most evident when ridden. Horses 4, 6 and 7 exhibited forelimb lameness. Forelimb lameness was evident in hand for Horses 4 and 7, but was only apparent on the lunge or ridden in Horse 6. Horses 5 and 8 had reduced range of motion of the neck on the lunge. Horse 6 was consistently more reluctant to trot willingly on the right rein on the lunge, although paradoxically right forelimb lameness was more obvious on the left rein compared with the right rein. Hopping-type forelimb lameness was not observed. When ridden two horses (H 5,6) tilted the head and neck, with the nose to the right and to the left respectively. Horse 5 had unrelated bilateral hindlimb lameness.

The right forelimb lameness in Horse 6 was not improved by any local analgesic technique and showed deterioration after palmar metacarpal (subcarpal) nerve blocks. The left forelimb lameness in Horse 7 was improved after intra-articular analgesia of the left Ce7-T1 articular process joint, and the horse could then easily lower the head and neck to eat from the ground. Diagnostic analgesia was not performed in Horse 4.

Haematological and serum biochemistry results were within the normal range in all horses. The donkey had mild neutrophilia and an increased serum haptoglobin concentration, but the total blood leucocyte count and fibrinogen concentration were within the normal range.

Radiological findings

The radiological features are summarised in **Table 2** (**Figs 1–4b**–). Three Equidae (D1 and H2,6) had intervertebral disc disease involving the intervertebral symphysis between C6 and 7; in three horses (H3,4,7) the articulation between C7 and T1 was involved. One horse (H5) had abnormalities of the intervertebral symphyses of both C7-T1 and T1–T2. In one horse (H8) the articulation between C2 and 3 was affected.

TABLE 1: Signalment, work discipline, duration of clinical signs (months) and summary of clinical features of eight Equidae with intervertebral disc disease of the cervical or cranial thoracic vertebrae

Identity	Age (years)	Breed	Work discipline	Duration of clinical signs	Depression	Forelimb lameness	Stumbling	Ataxia	Neck locking
D1	5	Donkey	Driving	1	+			+	
H2	1.5	WBL	Unbroken	6			+	+	
H3	12	WBL	Dr (PSG)	2					
H4	6	Akhal Téké	LDR	1.5		+			
H5	8	TB X	E	5					+
H6	5	Highland	GP	2		+	+		
H7	5	Pony	GP	1		+			
H8	8	WBL	Dr (N)	1					

Dr, dressage (PSG = Prix St Georges; N = Novice); E, Eventing; GP, general purpose riding; LDR, long distance riding (20 km); TB x, Thoroughbred cross; WBL, warmblood.

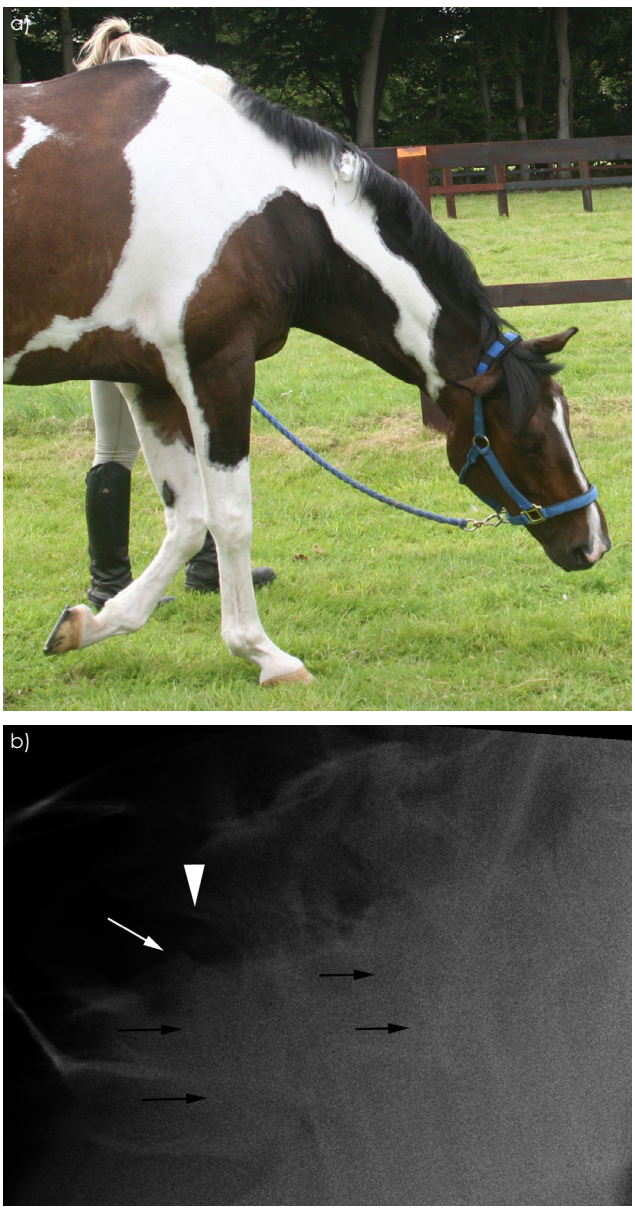

Fig 1: a) Horse 5 (see Table 1 and Fig 5) grazing with the neck in a 'locked', low position. The horse tended to knuckle forwards on the left metacarpophalangeal joint. The neck is turned to the right. The head is slightly tilted with the nose to the left. The right eye is partially closed. b) Lateral–lateral image of the seventh cervical (C7) and cranial thoracic vertebrae (T1–3). Cranial is to the left. There is complete loss of intervertebral disc space between C7-T1 and T1–2 (black arrows), with increased opacity of the caudal end plate of C7 and the cranial end plate of T1. There is new bone formation on the dorsal (white arrow) and ventral caudal aspects of C7. There is an ill-defined mineralised opacity dorsal to the intervertebral symphysis between C7 and T1 (white arrow head). There is asymmetrical enlargement of the articular process joints of T1–2, with marked decreased size of the intervertebral foramen.

Treatment and outcome

Donkey 1 was treated with doxycycline 10 mg/kg bwt per os b.i.d. for 5 months and showed progressive improvement,

TABLE 2: Summary of radiological features of eight Equidae with intervertebral disc disease in the cervical (C1–7) and cranial thoracic (T1–2) vertebrae

Equidae number	Radiological features
D1	Reduced and uneven intervertebral disc space C6–C7. Large semi-circular (about 3 cm × 1 cm) area of radiolucency with ill-defined, slightly irregular margins in the cranial end plate of C7 (osteolysis). Irregular and ill-defined caudal end plate of C6. Major surrounding increased opacity (in C6 and C7). Mild subluxation, with ventral displacement of C7. Enlarged APJs C5–6 and C6–7.
H2	Obliteration of the intervertebral disc space C6–C7. Large semi-circular (about 3 cm × 1.5 cm) areas of radiolucency with ill-defined, irregular margins in the caudal end plate of C6 and the cranial end plate of C7 with surrounding increased opacity. Subluxation, with marked ventral displacement of C7.
H3	Severe reduction of the intervertebral disc space at C7-T1. Ill-defined areas of radiolucency in the cranial end plate of T1. Minor surrounding increased opacity. Subluxation of C7-T1, with mild ventral displacement of T1. Enlarged APJs C6–7 and C7-T1 with narrowing of IVF. Transposition of ventral laminae from C6 to C7.
H4	Obliteration of the intervertebral disc space at C7-T1. Ill-defined focal areas of radiolucency in the cranial end plate of T1 and the caudal end plate of C7 (about 1 cm × 0.5 cm) facing each other. Extensive generalised increased opacity of caudal aspect of Ce7 and cranial aspect of T1. Irregular dorsal margin of the vertebral body of T1.
H5	Complete loss of intervertebral disc space C7-T1 and T1-2. Increased opacity of caudal end plate of C7 and the cranial end plate of T1. New bone formation on the dorsal and ventral caudal aspects of C7. Ill-defined mineralised opacity dorsal to intervertebral symphysis between C7 and T1. Asymmetrical enlargement of the APJs of T1–2, with marked decreased size of IVF.
H6	Complete obliteration of intervertebral disc space. Subluxation of C6–7 with dorsal displacement of C7, flattening of the cranial end plate of C7 and partial disruption of the dorsocranial aspect of the cranial end plate of C7 and the dorsal aspect of the caudal end plate of C6.
H7	Marked narrowing of intervertebral disc space C7-T1 with increased opacity of caudal end plate of C7 and cranial end plate of T1; concave depression in most cranial part of the cranial end plate of T1 and smoothly irregular contour of caudal end plate of C7. Dorsal and ventral modelling of the caudal end plate of C7. Ill-defined mineralised opacity traversing the dorsal aspect of intervertebral symphysis. Enlarged APJs C7-T1 with narrowing of IVF. Transposition of ventral laminae from C6 to C7.
H8	Marked narrowing of intervertebral disc space C2–3. Enlarged APJs C2–3.

APJs, articular process joints; D, donkey; H, horse; IVF, intervertebral foramen.

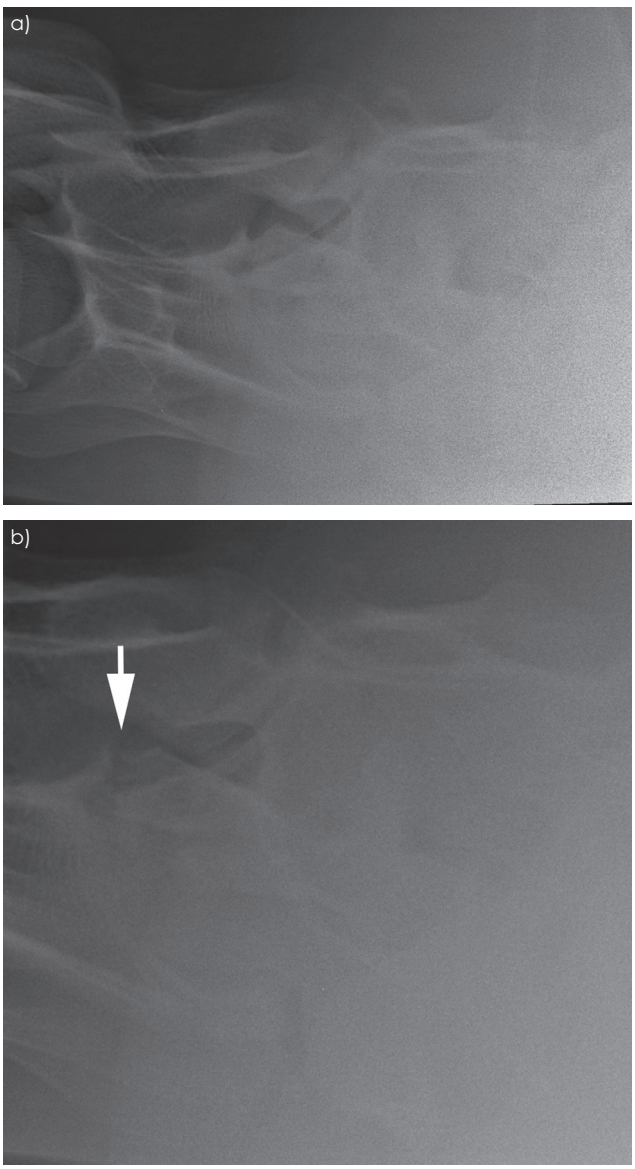

Fig 2: a) Slightly oblique lateral–lateral image of the sixth (C6) and seventh (C7) cervical vertebrae of Horse 6. Cranial is to the left. There is complete obliteration of the intervertebral disc space. There is subluxation of C6–7 with dorsal displacement of C7 and flattening of the cranial end plate of C7. b) Right 7^{0} dorsal – left ventral oblique image of C6 to the first thoracic vertebra. There is irregular contour of the dorsocranial aspect of the cranial end plate of C7 and the dorsal aspect of the caudal end plate of C6 (arrow).

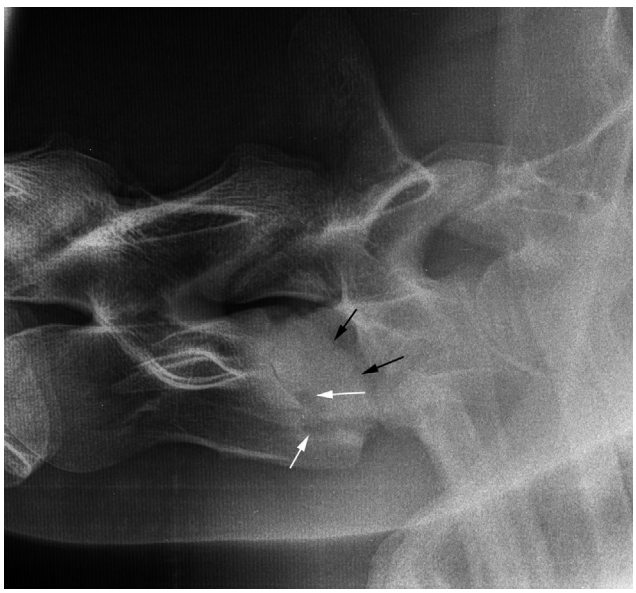

Fig 3: Lateral–lateral image of the seventh cervical (C7) to second thoracic (T2) vertebrae of Horse 4. Cranial is to the left. There is almost complete obliteration of the intervertebral disc space between C7 and T1. There are radiolucent areas in the subchondral bone of C7 and T1 (white arrows) surrounded by generalised increased opacity (black arrows). The articular process joints of C7–T1 have short pedicles.

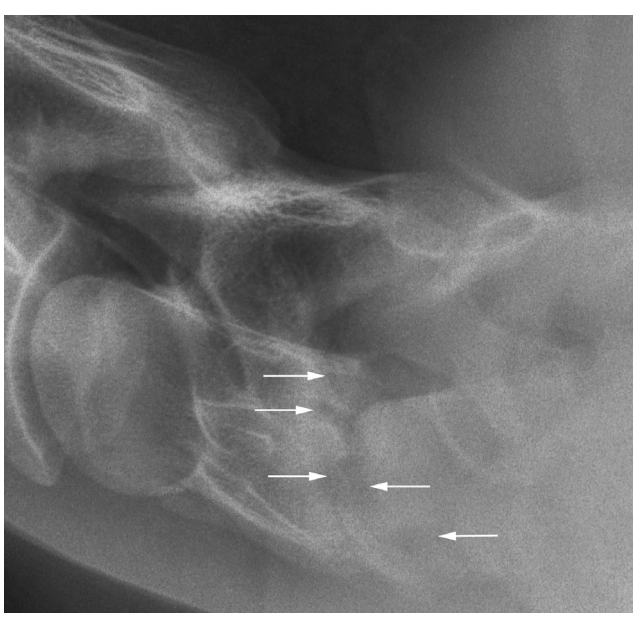

Fig 4: Lateral–lateral image of the seventh cervical (C7) to first thoracic (T1) vertebrae of Horse 2. Cranial is to the left. There are extensive areas of radiolucency in the caudal end plate of C7 and the cranial end plate of T1 (white arrows), with loss of the intervertebral disc space. There is marked ventral displacement of the cranial aspect of T1. This is a translational deformation, spondylolisthesis.

with resolution of clinical signs within 1 year. He remains clinically normal 5 years later, but was retired from driving. Horse 3 underwent surgical fusion of the C6–7 intervertebral symphysis at another clinic and has resumed work as an upper level dressage horse. Horse 4 underwent surgical fusion at another clinic, but was unable to stand after general anaesthesia, and was humanely destroyed after 3 days. Horse 7 showed transient improvement only after medication (methyl prednisolone acetate, 40 mg) of the left C6–7 articular process joints. Horses 6 and 8 were retired and Horses 2 and 5 were humanely destroyed, because of the severity of ataxia and the presence of chronic pain respectively. Post-mortem inspection of the boiled-out vertebrae of Horse 5 revealed multiple pitted lesions in the caudal end plates of C7 and T1,

and the cranial end plates of T1 and T2; the bone was otherwise eburnated (**Fig 5**). There was a rim of new bone around the articular margins of the intervertebral symphyses and extensive new bone on the ventral aspects of the vertebral bodies of C7, T1 and T2, the extent of which had not been appreciated radiologically (**Fig 1b**). The facets for the articulations of the first and second ribs on both the left and right sides had periarticular modelling.

Discussion

In the majority of Equidae in the current report it seems likely that the underlying cause of intervertebral disc disease was not infection. However, in small animals discospondylitis is defined as bacterial, or less commonly fungal or algal, spinal infection, usually haematogenous, beginning as an infection of end plates of the vertebral bodies through the highly vascular and slow-flowing metaphyseal and epiphyseal capillary beds with secondary involvement of the intervertebral disc (Kerwin 2015; Ruoff *et al*. 2018). The mean and median ages of the Equidae in this case series was lower than the mean age of the majority of horses presented for lameness or poor performance to both clinics (Parkes *et al*. 2013). It is also lower than the reported age of horses with discospondylitis (Foss *et al*. 1983; Nixon *et al*. 1984; Adams *et al*. 1985; Stadler *et al*. 1988; Furr *et al*. 1991; Hillyer *et al*. 1996; Colbourne *et al*. 1997; Sweers and Carsten 2006; Garcia *et al*. 2015). The advanced nature of the radiological abnormalities at the time of diagnosis, despite clinical signs having been recognised in six Equidae for $\leq$ 2 months, suggests that radiological changes probably predated clinical signs. No horse had a history of known trauma. The cause of intervertebral disc disease therefore remains open to speculation. It was suggested that such radiological abnormalities may reflect the end-stage of cervical vertebral stenosis, based on a horse which presented with ataxia (Speltz *et al*. 2006). However, in the current series only three of the horses had concurrent enlargement of the articular process joints at the same level as the intervertebral disc disease and narrowing of the dorsoventral height of the vertebral canal was not a major feature. It is notable that in four cases there was subtle to severe subluxation of the affected vertebrae. Vertebral malalignment may be due to angular deformation, which is potentially reducible, although contributing to segmental instability, or a translational defect, more correctly referred to as spondylolisthesis, based on the human literature (Jiang *et al*. 2011). Spondylolisthesis is reported in humans as a consequence of trauma or disc degeneration in the cervical spine. In cervical degenerative spondylolisthesis in human patients, degeneration of the disc and the articular process joints occurs first, in association with neck pain, which is considered to be the initial symptom.

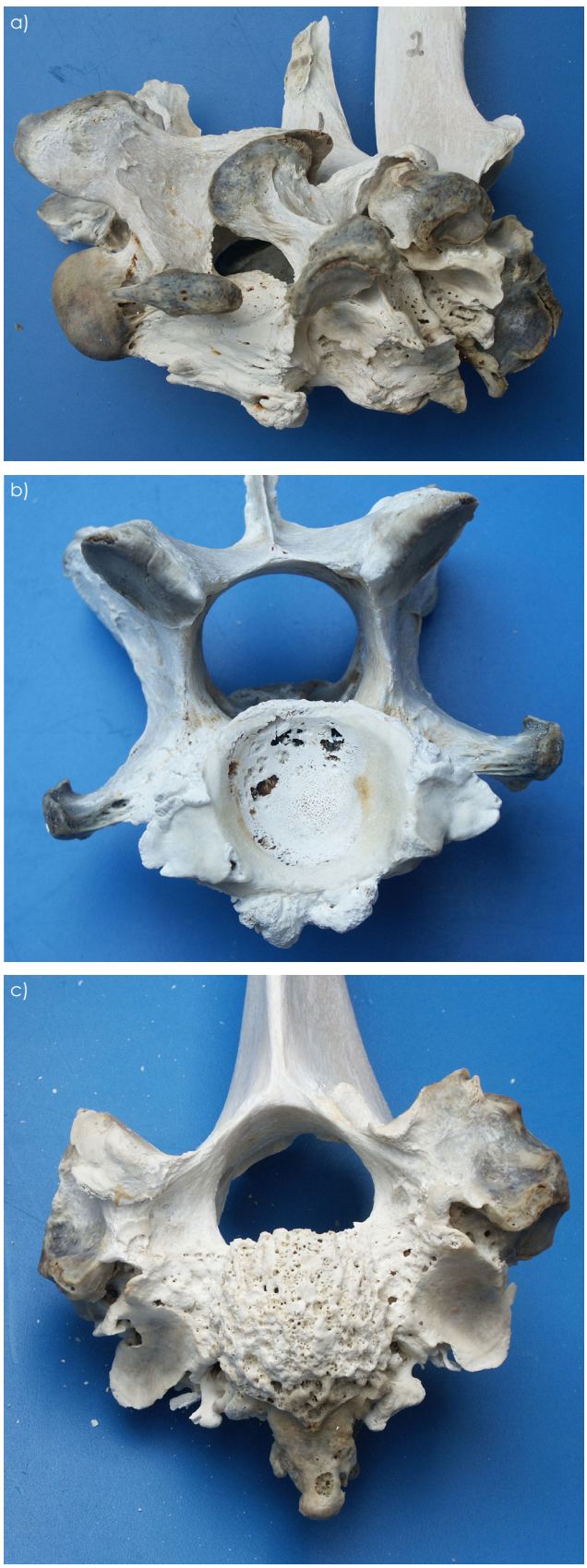

Fig 5: Osseous specimens from Horse 5 (see Fig 1). a) Lateral oblique image of the seventh cervical (C7) to second thoracic (T2) vertebrae. b) The caudal aspect of C7. c) The cranial aspect of T2. There is very extensive modelling on the ventral aspects of C7 to T2. There is major destruction of the caudal end plate of C7 and the cranial aspect of T2. There are severe bilateral costovertebral joint osteophytes of the first and second ribs.

Myelopathy and radiculopathy are also reported in association with spondylolisthesis. In the current case series, it is not known whether spondylolisthesis was primary, or developed secondarily to disc degeneration and joint instability. The high frequency of occurrence of degenerative changes in the intervertebral discs in the caudal cervical and cranial thoracic region (Bergmann *et al*. 2018) suggests that disc degeneration is primary.

Neck stiffness and an abnormal posture to graze were the most common clinical features. Difficulties in lowering the head to graze have been associated with congenital malformation of the occiput, atlas and axis (Dyson 2011) and with severe osteoarthritis of the articular process joints in the caudal neck region (Dyson 2011). One horse in the current series had concurrent osteoarthritis of the articular process joints of C7-T1 and both the ability to lower the head and forelimb lameness were markedly improved by intra-articular analgesia. To what extent intervertebral disc disease contributed to the clinical signs is difficult to determine. Lowering the neck to graze was a trigger for 'neck locking' in one horse (H5). It has previously been speculated that transient cervical nerve root compression may be a cause of 'neck locking' (Dyson 2011).

This horse (H5) showed a pain response on the caudal aspect of the left side of the neck only when the neck was 'locked'. In a previous study of horses with postulated nerve root compression, one horse with unexplained forelimb lameness showed focal hyperaesthesia ipsilateral to the lame limb, and a horse with episodic root signature posture had ipsilateral focal allodynia only when standing in this posture (Dyson 2018). Focal hyperaesthesia was reported in 48% of 91 horses with cervical vertebral compressive myelopathy (Levine *et al*. 2010). Hyperaesthesia may be related to compression of a nerve root, dura or dorsal horn lesions.

Two horses showed a propensity to stumble, which has been documented previously in association with lameness postulated to relate to cervical nerve root impingement (Dyson 2018). Three horses showed forelimb lameness, in one of which deterioration in lameness was seen after distal limb nerve blocks, a feature that has previously been recognised in horses with possible cervical radiculopathy (Dyson 2018). Head tilt was observed in two of the four horses assessed ridden, a clinical feature also observed in some horses with forelimb lameness, possibly related to cervical radiculopathy (Dyson 2018). One of these horses also exhibited a tilt of the neck and head when the horse walked with the neck 'locked'.

Post-mortem examination of Horse 5 revealed how radiography underestimated the degree of pathological abnormality of the affected vertebrae and rib articulations. The osseous changes of the vertebrae were similar to those described by Speltz *et al*. (2006).

In the majority of horses, the owners were reluctant to consider surgical fusion of the affected joints and for those with lesions caudal to C6–7 this would be logistically challenging. However, in one horse with lesions involving the C6–7 intervertebral symphysis surgical fusion was successful, allowing the horse to return to full athletic function as a dressage horse at Prix St Georges level. More horses require surgical treatment before the efficacy of this treatment could be assessed.

In conclusion, cervical intervertebral disc disease is an unusual cause of neck stiffness and an abnormal posture to graze and may be associated with forelimb lameness.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

The study was approved by the Clinical Ethical Review Committee of the Animal Health Trust (AHT 24 2018). Explicit owner consent for inclusion in this study was not sought, but all owners consented to the use of all case information and images for scientific publication.

Sources of funding

There were no sources of funding.

Acknowledgements

Annamaria Nagy, Sigrid Grulke and Simona Cerri for contribution of Equidae to the study.

Authorship

S. Dyson contributed to study design, study execution, data analysis and interpretation, and preparation of the manuscript. A. Salciccia and V. Busoni contributed to study design, study execution and data analysis and interpretation. All authors gave their final approval of the manuscript.

References

Adams, S., Steckel, R. and Blevins, W. (1985) Diskospondylitis in five horses. *J. Am. Vet. Med. Assoc.* **186**, 270-272.

Alward, A.L., Pease, A.P. and Jones, S.L. (2007) Thoracic discospondylitis with associated epaxial muscle atrophy in a Quarter Horse gelding. *Equine Vet. Educ.* **19**, 67-71.

Bassage, L.H. and Ross, M.W. (2011) Diagnostic analgesia. In: *Diagnosis and Management of Lameness in the Horse*, 2nd edn., Eds: M. Ross and S. Dyson, Elsevier Saunders, St. Louis. pp 100-135.

Bergmann, W., Bergknut, N., Veraa, S., Gröne, A., Vernooij, H., Wijnberg, I.D., Back, W. and Grinwis, G.C.M. (2018) Intervertebral disc degeneration in warmblood horses: morphology, grading, and distribution of lesions. *Vet. Pathol.* **55**, 442-452.

Bollwein, A. and Hanichen, T. (1989) Age related changes in the intervertebral disks of the cervical vertebral column in the horse. *Tierarztl. Prax.* **17**, 73-76.

Butler, J., Colles, C., Dyson, S., Kold, S. and Poulos, P. (Eds) (2017) The vertebral column. In: *Clinical Radiology of the Horse*, 4th edn., Wiley- Blackwell, Oxford. pp 531-607.

Colbourne, C.M., Raidal, S.L., Yovich, J.V., Howell, J.M. and Richardson, J.L. (1997) Cervical diskospondylitis in two horses. *Aust. Vet. J.* **75**, 477-479.

Denoix, J.-M. (2007) Discovertebral pathology in horses. *Equine Vet. Educ.* **19**, 72-73.

Dyson, S. (2011) Lesions of the equine neck leading to lameness or poor performance. *Vet. Clin. North Am. Equine Pract.* **27**, 417-437.

Dyson, S. (2018) Unexplained forelimb lameness possibly associated with radiculopathy. *Equine Vet. Educ.* Epub ahead of print. https://doi.org/10.1111/eve.12980

Foss, R., Genetzky, R., Riedesel, E. and Grahma, C. (1983) Cervical intervertebral disc protrusion in two horses. *Can. Vet. J.* **24**, 188-191.

Furr, M.O., Anver, M. and Wise, M. (1991) Intervertebral disk prolapse and diskospondylitis in a horse. *J. Am. Vet. Med. Assoc.* **198**, 2095-2096.

Garcia, E.B., Biller, D.S., Beard, L., Bawa, B., Nuth, E. and Goravanahally, M. (2015) Computed tomographic myelography of a foal with discospondylitis and extradural spinal cord compression due to a vertebral abscess. *Equine Vet. Educ.* **27**, 75-80.

Hillyer, M.H., Innes, J.F., Patteson, M.W. and Barr, A.R. (1996) Discospondylitis in an adult horse. *Vet. Rec.* **139**, 519-521.

Jiang, S.-D., Jiang, L.-S. and Dai, L.-Y. (2011) Degenerative cervical spondylolisthesis: a systematic review. *Int. Orthop.* **35**, 869-875.

Kerwin, S. (2015) Discospondylitis and related spinal infections in the dog and cat. In: *Advances in intervertebral disc disease in dogs and cats*. Eds: J.M. Fingeroth and W.B. Thomas. Wiley-Blackwell, Ames, Iowa. pp 161-167.

Levine, J., Scrivani, P., Divers, T., Furr, M., Mayhew, J., Reed, S., Levine, G., Foreman, J., Boudreau, C., Credille, B., Tennent-Brown, B. and Cohen, N. (2010) Multicenter case-control study of signalment, diagnostic features, and outcome associated with cervical vertebral malformation malarticulation in horses. *J. Am. Vet. Med. Assoc.* **237**, 812-822.

Nielsen, J., Berg, L., Thoefner, M. and Thomsen, P. (2003) Accuracy of ultrasound-guided intra-articular injection of cervical facet joints in horses: a cadaveric study. *Equine Vet. J.* **35**, 657-661.

Nixon, A., Stashak, T., Ingram, J., Norrdin, R. and Park, R. (1984) Cervical intervertebral disc protrusion in a horse. *Vet. Surg.* **13**, 154-158.

Nomina Anatomica Veterinaria (2005) *International committee on veterinary gross anatomical nomenclature*, 5th edn., Hannover, Columbia, Gent, Sapporo.

Olsen, E., Dunkel, B., Barker, W., Finding, E., Perkins, J., Witte, T., Yates, L., Andersen, P., Baiker, K. and Piercy, R. (2014) Rater agreement on gait assessment during neurologic examination of horses. *J. Vet. Intern. Med.* **28**, 630-638.

Parkes, B., Newton, R. and Dyson, S. (2013) An investigation of risk factors for foot-related lameness in a United Kingdom referral population of horses. *Vet. J.* **196**, 218-225.

Reed, S. (2003) Neurologic exam. *J. Equine. Vet. Sci.* **23**, 484-492.

Ruoff, C.M., Kerwin, S.C. and Taylor, A.R. (2018) Diagnostic imaging of discospondylitis. *Vet. Clin. North Am. Small Anim. Pract.* **48**, 85-94.

Speltz, M., Olson, E., Hunt, L., Pool, R., Wilson, J. and Carlson, M. (2006) Equine intervertebral disk disease: a case report. *J. Equine. Vet. Sci.* **26**, 413-419.

Stadler, P., Van Den Berg, S. and Tustin, R. (1988) Servikale intervertebrale diskus prolaps in 'n perd. *J. S. Afr. Vet. Assoc.* **59**, 31-32.

Sweers, L. and Carsten, A. (2006) Imaging features of discospondylitis in two horses. *Vet. Radiol. Ultrasound.* **47**, 159-164.

Yovich, J.V., Powers, B.E. and Stashak, T.S. (1985) Morphologic features of the cervical intervertebral disks and adjacent vertebral bodies of horses. *Am. J. Vet. Res.* **46**, 2372-2377.