Internal Fixation of Cervical Fractures in Three Horses

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Objective: To describe the surgical treatment outcome of cervical fractures in 3 horses.

Study Design: Case report.

Animals: Three client-owned horses with cervical vertebral fractures.

Methods: Three horses were referred for neck stiffness, pain, and ataxia after a cervical trauma because of a fall. Radiographic examination showed an oblique displaced fracture of the caudal aspect of the body of the second cervical vertebra (C2) in horse 1, an oblique displaced fracture of the caudal aspect of C4 involving the disc between C4 and C5 in horse 2, and a displaced transverse fracture of the body of the axis (C2) extending to the lateral arches and involving the vertebral canal in horse 3. In horse 1, the fracture was reduced and stabilized using a 14-hole narrow DCP plate, applied ventrally, and fixed with cancellous screws. A cervical fusion was performed. In horses 2 and 3, fracture fixation was performed using a 5-hole narrow LCP and 5 mm locking screws.

Results: All horses showed improvement and returned to full activity. The fracture healed in all horses.

Conclusion: Internal fixation of cervical fracture in these horses was associated with minimal complications, and was associated with healing and a highly functional outcome in all horses. The LCP was preferred and would be recommended for ventral stabilization of selected cases of vertebral fractures.

The reported incidence of vertebral fractures in horses, involving the cervical and thoracolumbar regions, varies.1 Adult horses can be injured in high-speed paddock or race accidents, which frequently result in catastrophic fracture displacement1 with major neurologic deficits causing recumbency. Few attempts have been made to surgically repair such injuries. In some cases, minimal spinal compression can occur in spite of obvious bone disruption. In this situation, bone healing may occur but neurologic sequela and recurrent pain because of exuberant callus or domino effect instability are common complications.1,2 In these situations, spinal cord compression may occur at intervertebral sites adjacent to the fusion as a result of chronic malalignment and instability. When malalignment has developed, internal fixation is a useful option to improve outcome and prognosis.2 This report describes the use of dynamic compression plate (DCP) in 1 horse and locking compression plate (LCP) in 2 horses for fixation of cervical fractures involving the body of cervical vertebra.

CASE 1

History

A 5-year-old 520 kg French warmblood gelding was referred with cervical trauma after a fall during the cross-country event of a 3-day competition. The referring veterinarian reported the horse showed neck stiffness and pain on palpation at the midthoracic region. The horse had been recumbent for the first 4 hours after injury, then recovered and was described as highly ataxic (grade 4/53) with considerable weakness in all 4 legs and intermittent falls when the neck was manipulated. The horse was administered phenylbutazone (Vetoquinol-Lure-France) at 4.4 mg/kg intravenously (IV) once daily, dexamethasone (MSD-Intervet-Courbevoie-France) at 0.1 mg/kg IV bid, and dimethyl sulfoxide (DMSO, LPG-Dinan-France) at 1 g/kg in Ringer’s lactate solution, IV, once daily. The horse appeared more comfortable and less ataxic, and was transported to the authors’ institution 48 hours after injury.

On admission, the horse held its head and neck in an extended position and the musculature at midthoracic region was contracted and painful to palpation. There was marked swelling in the region of the mid third of the neck, more pronounced on the left side. Grade 3 ataxia was noted with weakness and dragging of all 4 limbs. Lateral cervical radiographs showed an oblique displaced fracture of the caudal aspect of the body of the second cervical vertebra (C2) and an incomplete oblique nondisplaced fracture of the ventral aspect of C3. The fracture of C2 followed a plane parallel to the vertebral canal and involved the intervertebral disc between C2 and C3 (Fig 1A). The fracture of C3 was located at the
cranial aspect of the vertebrae and followed a more acute angle to the vertebral canal. The bone support of the vertebral canal appeared to be stable, with no communication toward the canal. Endoscopy of the upper airway did not reveal any abnormality.

Treatment

Phenylbutazone at 2.2 mg/kg IV bid and dexamethasone at 0.1 mg/kg IV bid were continued for 3 more days. Ataxia improved slightly but the horse still showed signs of pain, and was reluctant to walk and move the head. In the face of substantial fracture displacement, intervertebral disc involvement, grade 3 ataxia, and the possibility of development of exuberant callus after nonsurgical management, internal fixation was recommended.

Surgery

Phenylbutazone was continued and ceftiofur (MSD-Intervet-Courbevoie-France, 1 mg/kg IV once daily) and gentamicin (Ceva-Libourne-France, 6.6 mg/kg IV once daily) were administered. The horse was placed under general anesthesia in dorsal recumbency with the head extended. Custom-made wedges were used to stabilize the neck in a perfect sagittal position with good alignment of C2 and C3. After routine aseptic preparation and placing impermeable drapes, a 30 cm midline ventral skin incision was made centered on the affected intervertebral space, located with intra-operative radiographic guidance. The cutaneous musculature was bluntly dissected and the sternothyroid muscles were separated longitudinally to expose the trachea. Once the trachea had been identified, it was retracted to the left and blunt dissection was continued dorsally down the right side of the trachea, separating it from the carotid artery and vagosympathetic trunk. The longus colli muscles were now exposed and obviously disrupted in the region of C2. The carotid arteries and vagosympathetic trunks were protected and 2 self-retaining Inge retractors were placed to gain access to the ventral spine and adjacent vertebra. A periosteal elevator and mayo scissors were used to divide and separate the longus colli muscle at the level of C3 and expose the ventral surfaces of C2 and C3 vertebrae. The ventral spine of the body of C2 was flattened slightly using a curved osteotome and disc material was removed using multiple parallel drill lines with a 5.5 mm drill bit under radiographic guidance, stopping the drill 5–10 mm ventral to the cervical canal. The fracture was reduced by manipulation using bone forceps and strong digital pressure. A 14-hole narrow DCP plate was contoured and fracture fixation was achieved by bridging C2 and C3 with the plate, without any compression between C2 and C3 (plate applied in neutral fashion). Partially threaded, 6.5 mm cancellous screws were placed in lag fashion at the level of the fracture, in order to compress the fracture, while fully threaded 6.5 mm cancellous screws were placed in the other plate holes in a neutral fashion (Fig 1B). Radiographic guidance was used throughout the procedure to determine the appropriate drilling depth relative to the spinal canal. Calcium phosphate bone cement (Norian®, Depuy Synthes-Saint-Priest-France)
was placed within the disc space as a bone graft substitute to stimulate fusion of the disc space. A closed, active drain (Redon, Vygon-Ecouen-France) was placed under the muscle. The subcutaneous tissue and skin were sutured closed. The wound was protected with a stent bandage. Recovery was assisted with a single tail rope system and was uneventful.

**Clinical Outcome and Followup**

The drain was removed 3 days after surgery. Antibiotics were administered for a further 3 days and phenylbutazone was administered for 12 days at decreasing dosage. Food and water were placed at chest level for 2 weeks. At first the horse showed some signs of pain, especially when moving the neck, but progressively improved. Ataxia improved (to grade 1) by 8 days after surgery. The horse was discharged 15 days after surgery. The rehabilitation protocol included 2 months of stall confinement, followed by 1 month of hand walking and 2 months of progressive exercise. The horse improved rapidly after surgery and was used as a leisure horse during the first 6 months of exercise because of poor gait of the right forelimb suspected to be the result of residual cervical pain. The horse continued to improve and returned to full activity (jumping). Complete healing and intervertebral fusion were present on radiographs taken 5 months after surgery (Fig 2).

**CASE 2**

**History**

A 7-year-old 490 kg French warmblood gelding was referred for a fracture of C4 after a fall although show jumping the day before. The referring veterinarian had administered phenylbutazone at 4.4 mg/kg IV and dexamethasone at 0.1 mg/kg IV before transporting the horse. On presentation, the horse held his head and neck extended and appeared painful on palpation of the caudal third of the neck. The horse showed grade 2/5 ataxia. Lateral radiographs showed an oblique displaced fracture of the caudal aspect of C4 involving the disc between C4 and C5. The fracture plane was parallel to the vertebral canal (Fig 3) and the displacement was larger at the rostral part of the vertebra. In the face of marked displacement of the ventral vertebral body and possible development of exuberant callus with nonsurgical management, internal fixation was recommended. Anti-inflammatory treatment was continued and the horse underwent surgery 72 hours after injury.

**Surgery**

The surgical approach was as for horse 1. A 5-hole, narrow LCP and 5 mm locking screws were used. The fracture was reduced and stabilized without arthrodesis despite the disc involvement as the caudal adjacent vertebra was not affected. The fracture was difficult to reduce so the 3 caudal screws were first inserted into the fragment and locked into the plate, and then used as a lever arm to position the fragment back on to the parent bone. The plate was then secured to the body of C4 using the 2 cranial screws (Fig 4). Bone cement (Norian) impregnated with amikacin (Mylan-Saint Priest-France, 1 g) was applied under and around the plate after tightening the screws to reduce the risk of further penetration of the screws toward the vertebral canal in areas where the plate was not in a full contact with the bone. A closed active drain (Redon) was placed and the surgical site was sutured closed. Recovery was assisted with a single tail rope system and was uneventful.
Clinical Outcome and Followup
Postoperative care was as for horse 1. The horse was reluctant to lower his head and neck for approximately 1 week after surgery. Ataxia improved progressively and the horse was discharged from the clinic 2 weeks after surgery. At 3 months after surgery, radiographs showed almost complete bone healing with moderate collapse of the disc space. The horse had an intermittent irregularity of the right hind limb at a walk and trot (grade 1 ataxia). The horse was back to full activity at 6 months after surgery and was used as a leisure horse. Three years after surgery, the horse had a normal gait at trot and radiographs showed complete healing with no change in the position of the implant and no lysis around the implant (Fig 4). There was some peri-articular remodeling at the caudal epiphysis and irregularities at the disc space.

CASE 3

History
A 14-month-old 340 kg thoroughbred filly was referred for fracture of the axis (C2) after a fall in the field that had occurred 5 days previous. The filly was reluctant to move the head ventrally or laterally. The filly had grade 3 ataxia involving all limbs, more pronounced in the hind limbs. The filly had been receiving phenylbutazone at 4.4 mg/kg IV and dexamethasone at 0.1 mg/kg IV for 3 days prior. Lateral radiographs of the cervical region showed a displaced transverse fracture of the body of the axis (C2) extending to the lateral arches and involving the vertebral canal (Fig 5). Some fragmentation was apparent around the fracture line, especially at the lateral arches. Internal fixation was recommended.

Surgery
The neck was stabilized in extension and a pad was placed under the dorsal neck at the level of C2 until perfect alignment of C1 was achieved. The surgical approach was as for horse 1. The fracture was reduced by digital pressure and traction using bone clamps; however, the fracture was stabilized in a suboptimal reduction. A 5-hole LCP plate was bent slightly, applied to the ventral aspect of C2, and stabilized with 4 × 5 mm locking screws, placing 2 screws on each side of the fracture (Fig 6).

Clinical Outcome
The filly improved rapidly after surgery with reduced neck pain and normalization of the gait within 2 months. The filly had a normal gait 6 months after surgery and was put into training for flat-racing.

DISCUSSION
Cervical and thoracolumbar vertebral fractures in adult horses are reported, the result of hyperflexion, hyperextension, or lateral bending of the neck when falling. Fractures of C3 and C4 were most frequent in a report on racing adult horses. Cervical fractures are most frequently compression fractures of the vertebral body, followed by articular process fractures. Cranial cervical fractures are reported more often in young horses (<6 months of age) and can involve the axial dens or odontoid process. All fractures in the horses reported here were the result of a fall and involved C2/C3, C4, and C2, respectively. The configurations in horses 1 and 2 were similar with an oblique body-displaced fracture of C2 and C4 and disc involvement. The displacement was minimal over the disc but substantial at the mid vertebra. In horse 1, the fracture progressed through the disc to the cranial part of the adjacent vertebra, where a nondisplaced short oblique fracture of the cranial head of the vertebral body of C3 was observed. In horse 3, the fracture extended through the disc to the cranial aspect of C2, and stabilized with 4 × 5 mm locking screws, placing 2 screws on each side of the fracture.
3, the fracture followed a transverse plane at the mid body of C2 and was slightly displaced.

The neurologic deficits associated with cervical fractures vary. The horses reported here showed mild to severe ataxia but all were able to stand up spontaneously. All horses were reluctant to move their head and held their necks and heads extended. In horses 1 and 2, the fracture line did not extend to the vertebral canal. Ataxia may have been the result of direct trauma of the cord during the fall, or by disc impingement on the cord. In horse 3, the plane of the fracture progressed through the vertebral canal toward the lateral arches with some displacement. The filly remained ataxic (grade 3) after injury but without advanced imaging (computed tomography or magnetic resonance imaging) or myelogram, the extent of any spinal cord compression (for any case) is not known. Advanced imaging and orthogonal radiographs would also have better characterized the fracture configuration in these cases. In horses 1 and 2, internal fixation was recommended because of ventral displacement of the bony fragment. In both cases, fracture healing without fixation may have resulted in exuberant callus and bony bridging across the intervertebral space which may have caused further compromise. There is a possibility that instability could develop in adjacent discs to the fused space (domino effect), which has been reported after nonsurgical management of cervical fractures and luxation in horses. In such cases, spinal compression occurs at intervertebral sites adjacent to the fusion as a result of chronic misalignment and instability and can occur after injury-induced vertebral fusion (no surgery) or surgical fusion of cervical vertebrae lesions. In horse 3, reduction and stabilization was recommended to minimize callus formation, especially at the ventral border of the canal.

Surgical repairs of fractures of the odontoid peg (dens of axis) have been described in foals and include compression plating and Steinmann pin fixation. In adult horses, cervical fractures have been successfully treated by lag screw fixation, dorsal laminectomy, and ventral cervical fusion using Kerf cut cylinders. Dorsal application of a 7-hole, narrow DCP over the dorsal rim of C2 has been described for a displaced vertical fracture of C2. Ventral plating was used in all cases of the present report as has been described. The combined use of DCP plates, with fully threaded 6.5 mm cancellous screws, and ventral intervertebral fusion using a Bagby basket has been described previously. In horse 1, fusion between the fractured vertebrae was performed without a basket to avoid damaging the fracture fragments that extended into the disc space. The disc material was removed and replaced by an osteoconductive calcium phosphate cement (Norian) to promote fusion, which was verified on radiographs at 5 months after surgery. A DCP plate was applied with cancellous screws because LCP equipment was not available at the time. Ventral application of a DCP with cortical or cancellous screws requires the screws extend to and engage the dorsal cortex. In horse 1, the length of the first 4 screws was 4–6 mm shorter than the drill depth because of displacement of the plate toward the ventral bone surface. The following screws were 2 mm shorter than the drill depth. Radiographic guidance was used to aid drilling and screw depth selection, with care to reduce screw length by 10% to compensate for magnification. Applying a bone plate to the ventral aspect of the vertebrae violates the principle of plating the tension side of a bone. As a result, ventral flexion can lead to screw distraction from the bone and predispose the fixation to failure. Cranial extension of the plate can interfere with the normal articulation with the vertebral adjacent to the repair. In horse 1, there was some backing out of 1 cancellous screw but this did not interfere with healing. In horse 2, an LCP construct was used to improve stability but intervertebral fusion was not performed because the caudal vertebra was intact. There was no loosening of the implants noted on radiographs taken 3 years after surgery but there was considerable remodeling at the intervertebral space. Cervical fusion may have prevented this remodeling.

Use of an LCP for cervical fusion in horses has been described with screw pullout being the most common complication. Screw pullout only occurred in 1 screw in the DCP in the cases of this report. However, the intervertebral space was not bridged in the 2 cases with LCP, which would reduce cyclic loading on the plate and the chance of screw loosening. Lag screw fixation alone could have been used in horse 2 but the fracture was quite difficult to reduce and there was concern that lag screws would be insufficient. An advantage of application of LCP over DCP is the lessened need to have the plate applied in contact with the bone. However, the author suggests that for ventral application of a plate for cervical surgery in horses, especially when an intervertebral fusion is performed, both a DCP and LCP need to contact the bone. As the plate is not applied to the tension side, the screw located at the end of the plate could penetrate further into the bone during flexion of the neck, creating some instability of the construct and a risk of injuring the vertebral canal. The risk of this is enhanced by the thin thread of the 5 mm head locking screws but reduced by the fixed angle of the locking plate construct.

Reduction was difficult in horses 2 and 3 with concern that excessive manipulation of the fragments might damage the spinal cord. Custom-made wedges placed under the neck kept the vertebrae aligned and facilitated reduction of the fracture. These were made of radiotransparent plexiglass and also allowed insertion of the radiograph plates. In horse 2, the stability of the locking screws inside the plate allowed the plate to be used as a lever arm to reduce the fracture.

All horses improved quickly after surgery and all fractures were considered healed based on radiographic assessment. All horses returned to previous levels of activity. The first horse, despite its normal gait, was used for show jumping instead of 3-day events because the owner did not want to take any risk of a fall during cross country. In these 3 horses, plate fixation was sufficient to stabilize simple cervical fractures. The LCP was preferred and would be recommended for ventral stabilization of selected cases of vertebral fractures.

**DISCLOSURE**

The authors declare no conflicts of interest related to this report.
REFERENCES