C7-T1 ventral interbody fusions: Opportunities, nuances and expectations

John Janicek[1]

[1]Brazos Valley Equine Hospital - Salado

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Abstract

Caudal cervical spine pathologic lesions are a common cause of pain, lameness, ataxia, poor performance, or any mixture of these clinical signs. Combined radiographic and computed tomography myelography imaging of the caudal cervical spine is imperative when spinal cord compression, nerve root compression, and/or intervertebral disc disease is suspected. Surgical arthrodesis (ventral interbody fusion) of the C7-T1 articulation can be performed successfully and it is important for veterinarians to be aware that treatment at this level is possible.

C7-T1 ventral interbody fusions: Opportunities, nuances and expectations

John Janicek

Brazos Valley Equine Hospitals-Salado, Salado, Texas, USA

Correspondence: John Janicek

Email: john.janicek@bveh.com

Santos et al. (2023) describes an interesting case report of discospondylitis at the level of C7-T1 in a young horse that was managed surgically. This is the first report of surgical treatment for discospondylitis at this level in the horse and the authors should be commended for their efforts and surgical modifications to provide a successful outcome to the patient. Caudal cervical vertebrae are becoming a more recognized source of pathological conditions that clinically result in pain, lameness, ataxia, inferior performance or any combination of these clinical signs (Dyson, 2011).

The etiology of discospondylitis in horses remains unclear, but infection and trauma are often cited as the inciting cause (Moore 1992). Horses affected with discospondylitis can develop degradation of the intervertebral disc, collapse of the intervertebral space, dorsal protrusion of the intervertebral disc into the spinal canal, intervertebral foramen narrowing, and/or endplate osteolysis of the affected vertebrate (Figure 1).

Clinical signs of discospondylitis include cervical spine pain, stiff gait, and varying levels of ataxia that can originate from intertwined pathological processes. Horses with caudal cervical pathologic lesions often have uni- or bilateral atrophy of pectoral muscles, atrophy of muscles where the neck and shoulder muscles tie-in together, and antebrachial muscle atrophy. Interestingly in this case, cervical spine and forelimb stiffness were present without any ataxia. Cervical spine pain results in limited cervical spine range of motion and consequently a stiff gait. The pain can be severe enough that a facial grimace and/or "wide-eyed" appearance can be appreciated when the horse moves its head and cervical spine. Cervical spine pain can be attributable to instability caused by vertebral endplate osteolysis, and loss of intervertebral disc and collapse of the intervertebral space; pain can also be from vertebral endplate cartilage degradation

resulting in subchondral bone and nerve exposure. A stiff gait associated with discospondylitis not only comes from cervical spine pain but may also originate from caudal nerve root neuritis and/or nerve root compression. Caudal cervical vertebral spine (C6-T1) instability secondary to pathological changes associated with discospondylitis may result in intervertebral foramen narrowing causing nerve root compression and a stiff forelimb gait. Ataxia that occurs in cases with discospondylitis can be multifactorial. One explanation is the instability caused by vertebral endplate osteolysis and loss of intervertebral disc causing varying degrees of vertebral kyphosis resulting in cervical vertebral stenotic myelopathy. A second explanation of ataxia associated with discospondylitis would be dorsal protrusion of the intervertebral disc into the spinal canal because of collapse of the intervertebral space.

Horses with C7-T1 pathological lesions can be separated into two different classes. Class 1 patients present with a varying degree of neurological deficits that originate from dorsal and/or lateral spinal cord compression. Class 2 patients usually present with moderate to severe forelimb lameness that cannot be eliminated with forelimb peri-neural anesthesia or forelimb intra-articular anesthesia; these cases are often associated with intervertebral foramen stenosis of the caudal cervical spine or some level of intervertebral disc disease (Ricardi and Dyson, 1993).

Imaging the C7-T1 region can be a challenge as this area is covered by heavy muscle and the scapulohumeral joint often superimposes this region. Diagnostic modalities used to assess the caudal cervical spine include cerebral spinal fluid analysis, standing survey radiographs, nuclear scintigraphy, ultrasonography, cervical myelography, computed tomography (CT) and magnetic resonance imaging (MRI). In this case report, serial complete blood cell counts, and serum amyloid A measurements were used to help decide that an infectious process was under control. Cerebral spinal fluid culture and sensitivity along with cytology could have been viable options to help assess the presence of infection as well. Fan beamed CT myelography was performed in this case providing great detail about structures at C7-T1 which included collapsed intervertebral disc space, irregular shaped regions of lysis on vertebral endplates, ventral periosteal proliferation on vertebral endplates, and mild to moderate spinal cord compression. Multiplanar CT reconstruction and three-dimensional imaging using fan-beam CT technology is consistently attainable at the C7-T1 level with the horse under general anesthesia allowing for thorough examination of dorsal and lateral contrast dye columns, assessment of articular facet sizes, shapes, and associated pathologic lesions, permits for determining intervertebral foramen stenosis, and detection of disc degeneration. CT myelography should be considered the current gold standard for caudal cervical spine diagnostic imaging and pre-surgical planning.

Surgical fusion of the equine cervical spine was first reported by Wagner et al. in 1979 using the Bagby basket which has been modified over the past 40 years; currently a titanium fully threaded, or partially threaded Kerf-Cut Cylinder packed with cancellous bone graft is available for ventral interbody fusion and globally remains the mainstay for spinal fusions. Vertebral fusion using a locking compression plate for cervical vertebral stenotic myelopathy was first reported in a 3-month-old Warmblood filly (Reardon et al., 2009), which was followed by a biomechanical study comparing the locking compression plate to the Kerf-Cut Cylinder (Reardon et al., 2010). Results of that study indicated that the locking compression plate had higher biomechanical properties than the Kerf-Cut Cylinder; however, in order to obtain complete vertebral arthrodesis, a large portion of the intravertebral disc needs to be removed, which is difficult when applying a locking compression plate. The use of a polyaxial pedicle screw and rod construct was first was reported in a proof-of-concept study (Aldrich et al., 2017), followed by a retrospective study using the polyaxial pedicle screw and rod construct that included 10 horses over a 4-year period (Pezzanite et al., 2022). In that study, two horses were euthanized within the first year. In 6 of 8 horses with [?]1-year follow-up, ataxia improved by 1-3 grades, with an average improvement of 1.25 grades. In four horses, ataxia improved to grade 0-1. In two horses the gait was unaffected, but neck comfort improved (Pezzanite et al., 2022). Recently, an implant system consisting of a 3-D printed plate, cancellous screws and titanium cage was designed from a 3-D rendering of the equine cervical spine to contour along the ventral aspect of the cervical spine. Clinical outcomes of this cervical spine implant system are favorable (Rossignol, 2022). Excluding the Kerf-Cut Cylinder, all aforementioned techniques have substantial limitations to arthrodese C7-T1. Ventral interbody fusion of the C7-T1 articulation using the Kerf-Cut Cylinder and specialized long-handled instrumentation

has been performed for the past 10 years and is indicated when dorsal dye column compression is present on myelography and/or CT myelography, lateral spinal cord compression is present on CT myelography, intervertebral foramen stenosis is present on CT myelography, or when intervertebral disc disease is detected on CT myelography. Ventral interbody fusion of C7-T1 can be successfully performed in mature equine patients and results of an unpublished study by Grant et al. (2023) suggest that C7-T1 ventral interbody fusion has a good prognosis to improve comfort level, resolve lameness, and/or reduce the neurological grade that is safe for riding or provides a good quality of life (Figure 2).

The success of C7-T1 vertebral arthrodesis in this case using a 4-hole locking compression plate along with two transvertebral 5.5 mm cortical bone screws placed in place in lag fashion can be contributed to the light weight of the horse (weight was not reported, but a 3/9 body condition is reported) and the lack of an intervertebral disc, and intervertebral collapse. Although not reported in this case report, the use of cancellous bone grafting could have been used within the intravertebral disc space to help form a more solid C7-T1 arthrodesis. Access to the C7-T1 region requires retraction and securing the forelimbs caudally before the area is aseptically prepared and draped. The surgical approach to C7-T1 is no different than when performing ventral interbody fusion in the remaining cervical regions, but there are some noteworthy anatomical variables. Gaining access to and visualization of the C7-T1 area is a challenge because this site is deeper and partially obstructed by the cranial sternum. The truncus bicaroticus is the common trunk of the left and right common carotid arteries. The truncus bicaroticus lies dorsal to the caudal deep cervical lymph nodes and the bifurcation typically occurs directly over the C7-T1 articulation. The surgeon should be prepared for variable positions and length of the truncus bicaroticus. Careful dissection is necessary to allow for the common carotid trunk to be retracted from the drill site without damaging the vagosympathetic trunk. C7 does not have a ventral spinous process but does have two small chevron-shaped bony tubercles on the ventral midline in the mid-body area. High quality intra-operative radiographs are necessary during surgery for measurement purposes and proper implant placement at C7-T1.

The only reported complication after surgery in the report by Santos et al. (2023) was the development of Horner's syndrome. This complication most likely arose from applying too much pressure on the right vagosympathetic trunk. An anesthetic recovery complication associated with vagosympathetic trunk damage includes laryngeal spasm or right recurrent laryngeal nerve paralysis. This complication most likely occurs from inadvertent pressure on the recurrent laryngeal nerve during retraction for instrumentation at C7-T1. If the left recurrent laryngeal nerve was dysfunctional before surgery, then laryngeal spasm or complete laryngeal collapse can occur and be fatal. This complication can be reduced by performing a pre-operative endoscopic exam; if the left arytenoid is not abducting properly, then left recurrent laryngeal neuropathy is assumed and the surgical approach should be performed on the left side of the trachea.

It is important for veterinarians to be aware that diagnostics and treatment of varying pathological processes at the C7-T1 level is possible with a good prognosis. It is very important to assess C7-T1 when examining the cervical spine in horses. The advancements of CT myelography can help pre-operative planning and prognosticate for the owners. The Kerf Cut Cylinder continues to be the most common implant used for cervical spine fusion; however, innovative surgical options and new implant systems are imperative to continue to improve the area of cervical spine surgery. The current case report by Santos et al. (2023) highlights a unique way to perform ventral interbody fusion for discospondylitis at C7-T1 and adds another tool in our toolbox for cervical spine orthopedic surgery.

CONFLICT OF INTEREST

No conflicts of interest have been declared.

ETHICAL STATEMENT

Not applicable to this clinical commentary.

ORCID

John Janicek https://orcid.org/0009-0004-4188-716X

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FIGURES

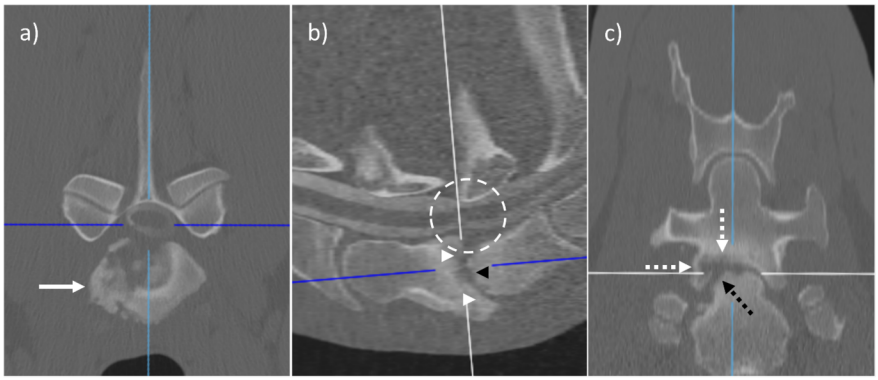

Figure 1: CT imaging centered on C7-T1 in the same horse. a) Coronal view showing endplate lysis (white arrow) and ventrolateral spinal cord compression. Moderate irregular periosteal proliferation is along the

right lateral and ventrolateral aspect of C7 vertebral body. b) Sagittal view showing endplate lysis of caudal C7 (white arrowheads) and cranial T1 (black arrowhead). The dashed circle is focused on dorsal protrusion of soft tissue into the ventral spinal canal and dorsal extradural spinal compression resulting in overall reduced dural diameter. The intervertebral disc spacing is markedly narrowed. c) Axial view showing endplate lysis of caudal C7 (dashed white arrows) and cranial T1 (black arrows).

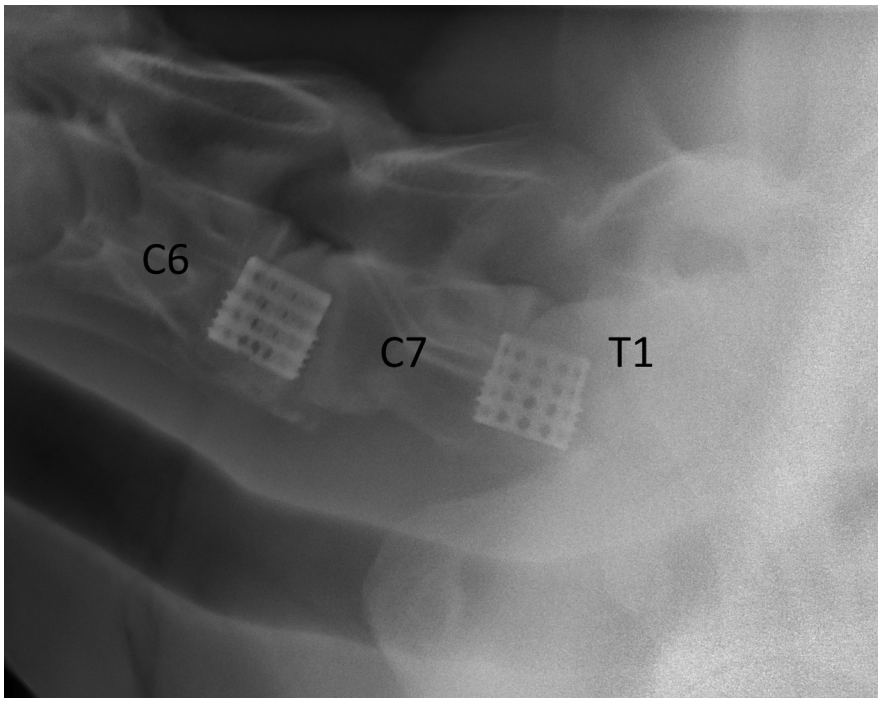

Figure 2: Radiograph obtained 1-year after ventral interbody fusion surgery for cervical vertebral stenotic myelopathy. Partially threaded titanium Kerf-Cut Cylinders packed with cancellous bone graft have been placed at C6-C7 and C7-T1.