**Comparison of two surgical techniques for treatment of canine caudal cervical spondylomyelopathy**

ABSTRACT:

Objective: to compare the prosthetic disc and the vertebral distraction-stabilization in dogs with caudal cervical spondylomyelopathy (CCSM) or disc associated wobbler syndrome (DAWS), by evaluating the clinical outcome and the imaging findings at different times after surgery

Study design: prospective cases series

Animals: 25 dogs suffering from CCSM and surgically treated by prosthetic disc (PD) or by vertebral distraction-stabilization (DS)

Methods: dogs presented with clinical signs and MRI findings compatible with CCSM that underwent surgery by implantation of the Adamo’s prosthetic disc (PD) or by vertebral distraction- stabilization (DS) with intervertebral cage, ventral locking plates and dorsal transarticular screws, were enrolled in this study. All dogs were then followed and evaluated clinically for a minimum of 1 year and radiographically for at least 3 months, to asses if there was improvement on neurological status, or implant failures like for instance subsidence; magnetic resonance exams were also repeated in selected cases

Results: 25 dogs fulfilled the inclusion criteria and Dobermann was the most represented breed (13/25). All dogs with CCSM surgically treaded either by PD implantation (12 cases) or DS (13 cases) underwent pre-operative radiographic and MRI assessment, and immediate post-operative x-rays. Three dogs from PD group dramatically deteriorated within 30 days from surgery: one had severe subsidence at 9 days with relapse of cord compression, and two with moderate subsidence had disc extrusion in the treated spaces, respectively at 15 and 30 days. All three required a second surgery. At 30 days recheck, 20 dogs improved neurologically, including the two re-operated at 9 at 15 days, 1 deteriorated (the other one with disc extrusion that underwent a second surgery) and 2 dogs were unchanged; one dog for each group had lost follow-up At 45 days a dog form DS group was diagnosed with discospondyltitis and was started on antibiotics. At 90 days revaluation, 21 dogs improved, including those requiring a second surgery or an antibiotic treatment, and 2 were unchanged. Overall, 9 of the 23 dogs deteriorated between 9 days and 36 months after surgery; 5 from the PD-group and 4 from the DS-group. Subsidence was identified in 9 out of 12 PD-dogs and tended to worsen over time. Subsidence tended to be more relevant when occurred sooner after the surgery. In the DS-group subsidence was identified in 5 of 14 cases and was overall milder and took longer than those treated by PD. Discospondylitis developed in 3 DS-dogs, respectively at 45 days, 5 and 10 months after surgery; in all cases it was responsible for neck pain and it was successfully treated with antibiotics. The radiographic follow-up was lost in one dog due to premature death for unknown causes. MRI was performed straight after the surgery in 7 cases (2 PD and 5 DS) and showed correct implant positioning with almost complete resolution of the cord compression in all of them; in association with radiographs it also highlighted the cause of deterioration (discospondylitis in 3 cases, disc extrusion in 2 cases and progression of the intramedullary damage in 1 case)

Conclusion: our preliminary results suggest that the prosthetic disc is more prone to clinical and radiographic failure than distraction-stabilization with cage, locking plates and transarticular screws, especially because of its high tendency to subside more dramatically and early after the surgery. The DS technique as reported herein is a valuable surgical option to treat CCSM dogs with a favorable medium to long term clinical and radiographic outcome.

INTRODUCTION:

Canine Caudal Cervical Spondylomyelopathy (CCSM), also known as Disc Associated Wobbler Syndrome (DAWS), affects large breed dogs and particularly Dobermann Pinschers, that over time become ataxic and paretic on all four limbs.1,4-8 Spinal cord compression and its damage due to degenerative disc disease and protrusion, hypertrophy of the dorsal longitudinal and sometimes the interarcuate ligaments are common denominator of the neurological signs.1,2,9-12 Although Magnetic Resonance Imaging is nowadays commonly accepted as the method of choice to establish the diagnosis, controversy still exits on how to treat this condition.3-7,9,16-20,46,47,49 A variety of surgical techniques have been proposed for CCSM, with many of the authors claiming success rates between 70 and 90 %.21-40 The distraction-stabilization of the affected vertebral segments and more recently the implantation of a prosthetic disc seem to currently represent both valid surgical options. 41-44 Despite their common goal is to relieve the spinal cord compression, a relatively normal vertebral motion should be preserved or restored with the prosthetic disc, whereas the vertebral fusion represents the final aim with the distraction-stabilization. 26-36 We prospectively selected dogs with CSM and then compared the prosthetic disc and the vertebral distraction-fixation, by evaluating the clinical outcome and the imaging findings, both radiographs and magnetic resonance images, at different times after surgery, posing special attention on subsidence.

MATHERIAL AND METHODS

Dogs presented to Diagnostica Piccoli Animali between January 2014 and September 2018, with clinical signs and MRI findings compatible with CCSM or DAWS that underwent surgery, were included. In every patients MRI was acquired in neutral position and after traction of the cervical vertebral column, as previously described. Surgery consisted in prosthetic disc (PD) implantation or vertebral distraction-stabilization (DS), obtained by using an intervertebral cage, two ventral locking plates and two dorsal trans-articular screws, all titanium made. The decision of making a full or a partial ventral slot in the treated spaces, depended on the residual cord compression on post-traction MRI images: if the compression did not fully resolved, a full ventral slot and disc removal were performed. Dogs undergoing PD implantation should have a complete resolution of cord compression after surgery. The neurological status and the radiographic appearance were evaluated pre- and post-operatively. Dogs after surgery were neurologically re-evaluated and the neurological status were compared to those pre-treatment, so they were rated as deteriorated, improved or normal, if no neurological deficits were noticed.The radiographs were taken immediately post-operatively and then repeated at regular intervals from 1 month to years after surgery. The radiographs mostly focused on subsidence, described as the percentage of distraction loss between the dorsal borders of the contiguous treated vertebrae and manually measured separately by the two authors on a dicom-viewer (Osirix ……….): subsidence was rated as mild if the percentage of distraction loss was <25%, moderate if 25-50% and severe if >50%. The degree of vertebral fusion/bone production for the DS dogs as the degree of residual motion for the prosthetic discs on dynamic x-rays (neutral, flexed and extend position of the cervical column) were also considered; when present, other changes such as screw rupture or signs suggestive of discospondylitis, were reported. MRI images were also repeated at different times after surgery: implant positioning, residual cord compression at the treated sites, new sites of cord compression, vertebral collapse or changes (e.g., bone lysis) and intra-medullary damage were evaluated.

Statistically analysis was performed using a Generalized Linear Mixed Model (GLMM) with Treatment (PD vs DS) and Observers (Obs1 vs Obs2) as fixed effects and ID-dog as random effects, to predict the grade of subsidence assumed have a gaussian distribution.

Intraclass-coefficient-correlation (ICC), as agreement measure between Observers, were calculated from variance components of the model.

Outcomes of surgery were classified in a categorical variable with three levels: “Improved”, “Stationary” and “Worsening”, the a multinomial logistic regression (MLR) were fitted to predict the outcomes using Treatment as predictor factor.

Two different MLR were fitted for outcomes observe after 30 days from surgery and after 90 day(?) respectively.

All data analysis were performed using R a programming language ( )

RESULTS

25 dogs fulfilled the inclusion criteria and Dobermann was the most represented breed (13/25); 4 were Weimaraner, 2 Bernese Mountain dogs and then 1 per each of the following: Rottweiler, Deutsch Kurzhaar, Hannoverscher Schweisshund, German Shepherd dog, Beauceron, and Mongrel. As per the inclusion criteria, all dogs with CCSM were surgically treaded either by PD implantation (12 cases: 2 cases C5-C6 and C6-C7, 10 cases C6-C7) or DS (13 cases: 2 cases C5-C6 and C6-C7, 11 cases C6-C7) and underwent pre-operative radiographic and MRI assessment. Mean surgery duration in PD-group was about 1 hour 30 minutes for dogs with one single space and 2 hours for those with C5-C6 and C6-C7; in the DS-group the mean duration was 3 hours for 1 single space and 4 hours for two sites. Despite rare, most common intra-operative complication was bleeding, especially when a full slot was performed. All dogs had immediate post-operative x-rays. All dogs were discharged within 24-36 hours after the surgery; mild deterioration was occasionally witnessed only in dogs that underwent full ventral slot and improved spontaneously in 5 to 10 days

Within the first month after surgery three dogs deteriorated, all from the PD-group: one became mildly ambulatory tetraparetic at 9 days because of severe subsidence and relapse of cord compression, as shown by repeat radiographs and MRI, and two dogs developed severe neck pain and mild to moderate tetraparesis respectively at 15 and 30 days, due to disc extrusion associated with moderate subsidence in the treated spaces, as shown by repeat MRI. These three cases required a second surgery: the first dog was treated by DS technique and the spinal cord compression was relieved in the other two cases by removal of the extruded disc through a lateral hemilaminectomy.55

23 dogs were available for clinical revaluation at 30 days: 20 dogs neurologically improved, also considering the dogs that required a second surgery (one PD-dog with severe subsidence and then treated with DS technique at 9 days and one PD-dog with disc extrusion and then treated with lateral hemilaminectomy at 15 days), 2 dogs were unchanged, 1 deteriorated (a second dog from PD-group with disc extrusion at 30 days); of the 2 dogs that could not be evaluated, one treated by DS suddenly died about three weeks after surgery for unknown reason and one treated by PD was not available for follow-up because the owners felt their dog showed a dramatic improvement and then did not require further diagnostics. At 45 days one dog from DS-group was re-evaluated for onset of neck pain: x-rays and MRI showed changes compatible with discospondylitis and treatment with amoxicillin and clavulanic acid (20 mg/kg BID) in association with enrofloxacin (5 mg/kg SID) was initiated.

All 23 dogs were clinically re-evaluated at 60 and 90 days: 21 neurologically improved, including those that underwent a second surgery or developed a discospondilitys; 2 dogs were still unchanged. Further radiographs were repeated in all 23 dogs at 30 and 90 days; 4 of these 23 dogs also had extra-radiographs at 6 months and 2 over 1 year. Overall, 9 of the 23 dogs deteriorated between 10 days and 36 months after surgery: 5 from the PD-group (42%) and 4 from the DS-group (28%). The 5 dogs that deteriorated in the PD group all had subsidence and 2, as said before, developed also a disc extrusion at the surgical site: all dogs became painful and 3 developed tetraparesis, which was mild in one case and moderate to severe in the remaining two dogs. Overall, subsidence was identified in 10 out of 12 PD-dogs (83%), it tended to become more evident over time, and varied from mild in 3 patients (20-30%), to moderate in 3 dogs (31-50%) and severe in 4 cases (>50%) The 2 dogs with disc extrusions had moderate subsidence; the PD-dog that deteriorated at 9 days and was treated with DS had severe subsidence. The remaining three with severe subsidence had a relevant new bone production and almost complete vertebral fusion at 90 days radiographic recheck in 1 patient; in two patients mild residual vertebral movement was still present. Of these three dogs, one was unchanged compared to the preoperative assessment, and two only had minor deterioration of clinical signs, characterized by stiff gait and neck pain and were treated conservatively with non steroidal anti-inflammatory drugs (carprofen 2 mg/kg BID) and gabapentin (10 mg/kg BID); neck pain dramatically improved in both dogs, but not the gait; 2 PD dogs had no subsidence on 30 and 90 days radiographs and both neurologically improved. In the PD group the degree of vertebral motion, evaluated in flexed and extended neck position, was preserved in only 2 dogs (both without subsidence), while it was decreased to absent in the remaining ones, in proportion to the severity of subsidence:a high tendency to vertebral-fusion with new bone production and spondylosis were most likely if subsidence was moderate or severe.

In the DS group it was also enrolled the dog previously treated with PD that required a second surgery at 9 days because of severe subsidence with relapse of cord compression, bringing up the DS-group from 13 to 14 patients available for follow-up. Of the 4 dogs that deteriorated in the DS-group, 3 developed discospondylitis (21%; 1 at 45 days, 1 at 5 months and 1 at 10 months) and 1 had moderate subsidence and progression of the intramedullary damage as showed by the MRI at 36 months re-check: all dogs manifested neck pain, and only the latter one had worsening of the neurological status, becoming more ataxic on the back limbs and hypometric on the front ones. Subsidence was overall identified in 5 of 14 DS-cases (36%) and was rated as mild in 3 cases (20-30%) and moderate in 2 (31-50%); no dogs suffered from severe subsidence. Subsidence was associated with screw rupture in 3 cases (1 screw in 2 cases and 1 screw in 1 case) and with discospondylitis in 1 case (45 days after the surgery) and with no major radiographic implant failure or other evident causes in the remaining case. Discospondilytis was successfully treated with antibiotics in all three cases (amoxicillin and clavulanic acid plus enrofloxacin as stated before), with the duration of the treatment varying from 60 to 90 days. 8 dogs had no subsidence at 3 months: 5 of those dogs showed also no subsidence when x-rays were repeated later, respectively at 6, 10, 12, 16 and 36 months. Good bone production-vertebral fusion was witnessed in all dogs but it became radiographically more obvious after 90 days.

A minimum of 1 year follow-up was available for 23 dogs: 21 dogs improved, also those requiring a second surgery or medical treatment; 2 dogs had an unchanged neurological examination. At 2 year telephone follow-up 18 owners reported an unchanged status from last time, but one of the stable dog mildly deteriorated becoming more ataxic. Only 6 dogs were available for follow-up at 3 years, including the dog that already deteriorated at 2 years: this dog received an MRI scan at this stage and a progression of the intramedullary damage was deemed responsible for the worsening ataxia and paresis of all four limbs.

Overall MRI was repeated in 14 patients (7 PD and 7 DS) for a total of 18 studies: 7 were acquired immediately after the surgery, 1 at 9 days, 1 at 15 days, 1 at 30 days and 1 at 45 days post-operatively because of worsening of the neurological status, 4 at 90 days post-op, and in 3 cases at 6, 12 and 36 months respectively. The 7 MRI scans done immediately post-operatively (2 PD-dogs and 5 DS-dogs) showed good implant positioning with none to minimal residual cord compression in all cases. Amongst the remaining cases MRI revealed intervertebral disc extrusion and moderate-severe subsidence with worsening of cord compression in 2 and 3 cases respectively, all treated by PD implantation. In the DS-group MRI confirmed the radiographic suspicion of discopondylitis in 3 cases, showed progression of the intramedullary damage in two dogs (at 6 and 36 months re-check respectively), and it was unchanged in 2 cases compared to those acquired immediately after surgery, despite screw rupture and mild to moderate subsidence were evident on radiographs in both cases. Amongst the dogs with progression of the intramedullary damage, only that one receiving the MRI at 36 months deteriorated clinically as previously described.

STATISTICA

Subsidence.

The results of GLMM are reported in tab. x

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Subsidence** | | |
| *Predictors* | *Estimates* | *95%CI* | *p* |
| Treatment [DS vs PD] | -29.03 | -47.78 – -10.28 | 0.002 |
| Observer [ob2 vs ob2] | 0.48 | -1.67 – 2.62 | 0.662 |
| **Random Effects** | | | |
| σ2 | 13.77 | | |
| τ00 IDdog | 518.27 | | |
| ICC | 0.97 | | |
| N IDdog | 23 | | |
| Observations | 46 | | |

Surgery outcomes

DISCUSSION

Preliminary results from this study suggest that canine caudal cervical spondylomyelopathy could be surgically treated with success;21-38,44 however, prosthetic disc is more prone to clinical and radiographic failure than distraction-stabilization with cage, plates and trans-articular screws.

Canine caudal cervical spondylomyelopathy (CCSM) or disc associated wobbler syndrome (DAWS) in Dobermann and in other large breed-dogs more frequently affect the C6-C7 intervertebral disc space, in association with involvement of C5-C6 in about 35% of the cases, with subsequent single or multiple compression and damage of the spinal cord.1-5,10 The changes causing the spinal cord compression are mainly represented by disc protrusion and hypertrophy of the dorsal longitudinal ligament;1-5,10-11 they might be static or dynamic, based on the variability of the degree of cord compression with flexion, extension, and traction/distraction applied to the cervical spine. 1-3,10,12-15,20,48 According to the dynamic response on myelographic, computed tomography or MRI studies, it is possible to distinguish between static and dynamic lesions or, more correctly, between traction non-responsive and traction-responsive cord compressions.1,10,12,14,15,17,19-20,49,54

Despite the treatment for dynamic CCSM lesions is still controversial, medical management generally results only in transient clinical improvement, and progression to severe tetraparesis is common.1,6-7,45 A recent study found that a beneficial outcome was associated with nonsurgical treatment in 54% of dogs and with surgical therapy in 81% of dogs; however, the difference between these two outcomes was not statistically significant.1,6-7,10 Overall, there is the tendency of considering the surgical treatment superior than the conservative one, especially with regards to medium-long term improvement.6 A variety of surgical techniques have been proposed for CCSM, with success rate varies between 70 and 90 %.21-40 ,44 The goal of surgical intervention is improving the neurological deficits or at least to stop or slow down their progression, by relieving the spinal cord compression and stabilizing the cervical vertebrae, anytime a dynamic component is suspected1,10 Various types of spinal decompression and vertebral stabilization techniques were reported for the treatment of cervical disc pathology in humans and the use of intervertebral body cages with or without adjuvant locking plates to achieve interbody arthrodesis rapidly gained acceptance and more recently it became popular also in dogs.50-53,30-36 Based on our previous experience on more than 30 cases, the use of the intervertebral cage alone was often insufficient to maintain the required inter-vertebral body distraction, despite the good clinical outcome. We therefore developed a system where the interbody spacer was also supported by the use of two ventral parallel locking plates and two dorsal transarticular screws through the affected facets, similar to what previously described.58 As opposed to the vertebral distraction-stabilization, another theory more recently suggested in dogs with DAWS, also inspired by the human counterpart, is that a normal vertebral motion should be preserved or restored and for this purpose a prosthetic disc has been designed, with the goal also to provide vertebral distraction and neural decompression41-44,51-52 We then decided to compare these two very different surgical techniques, by evaluating the clinical and the radiographic outcome at different time after surgery and, as previously stated, the prosthetic disc resulted more prone to failures in a relatively short period after surgery.

In fact, even if the surgery led to short time neurological improvement in almost all cases regardless of the surgical technique, many of the PD-treated patients tended to deteriorate within the first one or two months, whereas DS-dogs have fewer complications, less severe and later. More specifically, about 42% PD-patients deteriorated within 9-45 days after the operation, mostly due to moderate-severe subsidence associated with worsening of cord compression, in conjunction with disc extrusion in two cases. In most of these cases a second surgery was necessary to relieve the spinal compression and to counteract the effects of subsidence. We hypothesized that the discs extruded in two cases as a consequence of collapse of the intervertebral disc space that forced the residual disc material into the vertebral canal. The selection of a surgical technique should take into consideration the success rate as well as the potential risks of complication such as implant failure, potentially related also to subsidence in CCSM patients.10,25-37,44 Subsidence is in fact commonly witnessed with many of the surgical techniques used to treat CCSM and, from its human counterpart, it has been defined as sinking of a body with a higher elasticity modulus (e.g. graft, cage, spacer) in a body characterized by a lower elasticity modulus (e.g. vertebral body), resulting in 3D changes of the spinal geometry and eventually in a partial o total failure of the vertebral distraction-stabilization.44,50,52,53 Although even in human neurosurgery there is no general agreement regarding its role into the complications after cervical fixation-fusion surgeries, it seems to predispose to implant failure and then it should be avoided. Many studies have been conducted with the primary goal to identify surgical techniques capable of minimizing or eliminating the subsidence. As also for the data showed herein, subsidence is not only a radiographic failure but it is often associated with clinical deterioration, especially when moderate or severe and happens early in the post-operative period. Subsidence was witnessed in more than 80% of PD-cases, with only two dogs not showing any signs of subsidence and maintaining a good vertebral motion, supporting that the subsidence could be deleterious for a good outcome. Potential cause for the high incidence of subsidence in the PD-group is most likely represented by the small size of the artificial disc, when compared to the size of the intervertebral space; we in fact hypothesized that the loading surface of the prosthetic disc is too small compared to those of the vertebral end plates, which eventually tend to incorporate the disc itself. Moreover, we believe that its stiff nature is not capable to adsorb the vertebral movements of the caudal cervical region without sinking into the vertebral end plates themselves. As a direct consequence of such severe subsidence, the caudal cervical vertebrae lost the distraction and tended to fuse, either partially or totally, also lacking the restored motion.

Most common causes for deterioration in DS-dogs were discospondylitis, which developed in three cases, about 20% of all DS cases; one case worsened due to the progression of intramedullary damage as identified at three years post-operative MRI recheck. With the exception of one case, where discospondylitis developed at 45 days after surgery, in the other two dogs it developed relatively late, respectively at 5 and 10 months. Though in the first cases a direct relationship with the surgical procedure is likely, in the remaining two dogs we did not identified a relevant correlation. However, we felt that the surgery would cause an impact on the normal local environment, predisposing the development of bacteria, as it could have happened with any other spine surgery and not necessarily because of the presence of the synthetic material.56,57 Indeed, all cases improved after a relatively short course of antibiotics, without the need to remove the implants. Subsidence was rarer and of milder degree in DS cases than those in PD dogs; MRI in these cases however did not show relevant new or relapse of cord compression, possibly because of the mild vertebral collapse. We hypothesized that the most common cause for subsidence in these cases was linked to the screw rupture, like witnessed in three out of five cases. The breaking of the screws, even if rare, could be caused by the choice of too small diameters, by an anomalous angulation of the screws themselves, possibly in association with an excessive physical activity of the patient, especially in the first weeks after surgery.

A major disadvantage of DS technique as described here is the long time of the operation, especially if two adjacent sites needed to be stabilized, both ventrally and dorsally. However, this time may be reduced with experience; the mean time reported in this case series is influenced by longer duration for the initially treated cases. Both PD and DS techniques had very low complication rate and short hospital stay; so they were both considered two safe procedures to treat CSM dogs.

The small number of cases represent a major limitation of this paper, so further studies are required to draw more definitive conclusions. However, preliminary results support the evidence that distraction-stabilization technique as described here represents a valuable option to treat CCSM dogs and, despite some minor complication such as discospondylitis and/or screw rupture, it was deemed superior than the prosthetic disc currently available, leading to a better medium to long term clinical and radiographic outcome.