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ORIGINAL RESEARCH

Effect of local epidural application of methylprednisolone acetate on time to ambulation in non-ambulatory dogs with thoracolumbar intervertebral disc disease: A prospective randomised, blinded control trial

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Abstract

Background: The objective of this study was to analyse the potential benefit of the epidural application of steroids on time to ambulation in non-ambulatory dogs affected by intervertebral disc disease (IVDD) treated with decompressive surgery.

Methods: This prospective, randomised, blinded control trial involved 41 dogs with thoracolumbar disc extrusion, which were randomly allocated into two groups. In the control group, saline was locally applied after surgical decompression of the spinal cord ($n = 23$). In the treatment group ($n = 18$), local epidural application of methylprednisolone acetate (1 mg/kg) was used. Ambulation time was the primary outcome measure, defined as the ability to take 10 independent steps.

Results: The median number of days to ambulation was 7 days (range: 1–17 days) for the control group and 3 days (range: 1–8 days) for the treatment group. One dog from the treatment group developed discospondylitis and abscess formation.

Limitations: The study's heterogeneity in dog breeds, ages and pre-existing health conditions could affect the generalisability of the findings.

Conclusion: Epidural methylprednisolone acetate applied locally at the time of surgery may accelerate recovery in dogs following IVDD surgery.

INTRODUCTION

Intervertebral disc disease (IVDD) is the most common pathological condition affecting the canine thoracolumbar vertebral column, usually due to disc extrusion or protrusion.[1,2] The standard treatment for non-ambulatory dogs suffering from intervertebral disc extrusion (IVDE) is surgical decompression.[3,4] Nursing care of non-ambulatory dogs can be challenging and may increase treatment costs.[5] Therefore, various treatment strategies to shorten the time to ambulation in paraplegic dogs have been published, including subcutaneous administration of a metalloproteinase inhibitor and dimethylsulphoxide, postoperative physiotherapy and perilesional photobiomodulation, each of them resulting in variable success rates.[6–8] Specifically, Levine et al. found that the subcutaneous administration of a metalloproteinase inhibitor resulted in significant improvement in ambulatory status, with treated dogs showing a mean motor score of five compared with two in the control group, representing a 150% improvement.[6] Zidan et al. reported that dogs receiving more intensive postoperative rehabilitation, including underwater treadmill sessions, had a higher likelihood of regaining ambulatory ability, with a significant difference in recovery rates between those receiving intensive therapy and those receiving basic rehabilitation.[7] Bruno et al. investigated perilesional photobiomodulation therapy and found that although there was a trend towards a shorter mean time to regain ambulatory ability in the laser therapy group (14.2 vs. 24 days in the control group), the difference was not statistically significant.[8]

An IVDE is a localised displacement of disc tissue into the epidural space,[9] causing mechanical compression and secondary injury of spinal nerves and the spinal cord, resulting in ischaemia and initiation of the inflammatory cascade.[10–12] Most dogs exhibit an epidural inflammatory response, ranging from acute neutrophil invasion to chronic granulation tissue formation.[3,13–15] The degree of inflammation was significantly inversely correlated with the ability to regain ambulation in a study involving 105 chondrodystrophic dogs.[13]

Furthermore, IVDE-associated spinal cord injury (SCI) provokes an intramedullary inflammatory response that generates substantial secondary damage within neural tissue.[13] Studies in rodents indicate that potentially destructive neutrophils and activated microglia, replete with oxidative and proteolytic enzymes, occur within the first few days after SCI.[11,16] Experimental work in mice suggested that inflammation during the chronic phase following SCI reduces conduction through the epicentre of the lesion, possibly by the release of cytokines.[16] These data suggest that anti-inflammatory and neuroprotective strategies may be beneficial in dogs with IVDE.

However, studies in dogs have revealed that systemically administered methylprednisolone sodium succinate (MPSS) does not significantly improve recovery in canine SCI compared to other treatments and is associated with severe side effects, although the effects of its local application remain unassessed.[13,17–22] Epidural steroid injections have been used successfully for the treatment of lower back pain caused by lumbar disc herniation in people.[13,17–22] In dogs, treatment of lumbosacral degenerative stenosis by epidural infiltration with methylprednisolone acetate (1 mg/kg) was safe and yielded successful results in 79% of the cases in one study.[23] Furthermore, a more recent prospective study by Gomes et al. reported short-lived improvement in 84.4% of cases following a single dose of epidural methylprednisolone in dogs undergoing decompressive surgery for degenerative lumbosacral stenosis with foraminal stenosis due to L7-S1 chronic disc protrusion.[24]

Based on previous experimental, histopathological and clinical data,[16,25–32] and given that steroid hormones can freely diffuse across cell membranes[33,34] and steroids such as 17β-estradiol have been shown to enhance locomotor function and provide neuroprotection through various mechanisms,[35] we hypothesised that local steroid application could have an anti-inflammatory effect within the epidural compartment and possibly improve recovery of spinal axons after SCI. Our goal was to analyse the potential benefit on clinical outcome measured by the time to regain ambulatory status in dogs presented with non-ambulatory paraparesis with intact nociception following IVDE and treated via decompressive surgery. Our hypothesis in this prospective, randomised clinical study was that dogs with methylprednisolone acetate applied locally at the time of surgical decompression would regain ambulatory function more rapidly than the control group.

MATERIALS AND METHODS

Animals

Dogs presented with non-ambulatory paraparesis with intact nociception, diagnosed with an acute thoracolumbar IVDE via MRI, and treated via decompressive surgery were prospectively enrolled in the study. The study was approved by the Swiss National, Cantonal and Institutional Animal Care and Use Committees (approval number: ZH172/2022), and signed consent was obtained from all clients at the time of enrolment. The data collection and analysis were carried out in the small animal clinic of the faculty of veterinary medicine at the University of Zurich.

Dogs first underwent a full physical, orthopaedic and neurological examination by a board-certified neurologist (F.S.) to assess the presence of pathology associated with thoracolumbar myelopathy and to determine the degree of severity. This was followed by an MRI scan to confirm the presence of an IVDE, after which decompressive surgery was performed. The sensorimotor status of the dogs was scored according to Moore et al. using the modified Frankel score (MFS).[36] Briefly, according to this grading system, grade 0 dogs are those with paraplegia and absent superficial and deep pain sensation, showing no response to skin or bone clamping and no movement of the hindlimbs. Grade 1 dogs have paraplegia with intact deep pain sensation but absent superficial sensation, responding only to bone clamping with no hindlimb movement. Grade 2 dogs exhibit paraplegia with intact superficial and deep pain sensation, responding to both stimuli but with no hindlimb movement. Grade 3 dogs have non-ambulatory paraparesis, showing movement in one or both hindlimbs but unable to take 10 consecutive unassisted weight-bearing steps. Grade 4 dogs are ambulatory with paraparesis and are capable of taking 10 consecutive unassisted weight-bearing steps, although with an ataxic or paretic gait. Grade 5 dogs have a normal gait but exhibit paraspinal hyperaesthesia, with posture or physical examination findings indicating hyperaesthesia. Grade 6 dogs have normal neurological function.

For the purpose of this study, dogs with an MFS of 2 or 3 were pooled into one category and classified as 'non-ambulatory'. Dogs receiving presurgical systemic steroids and dogs with multiple affected sites were excluded from the study. The dogs meeting the inclusion criteria were then randomly assigned to one of two groups. The randomisation was executed using a random number generator, ensuring that each dog had an equal chance of being allocated to either group. Each dog was treated with routine decompressive surgery via mini-hemilaminectomy with removal of the herniated disc material from the vertebral canal and subsequent power-assisted fenestration of the affected intervertebral disc space. The first group was treated routinely with decompressive surgery following standard-of-care procedures (see below). After completion of the decompression and

before closure, the surgeon applied saline locally by splashing (control group, $n = 23$). The second group (treatment group, $n = 18$) underwent the same procedure, but methylprednisolone acetate (1 mg/kg) was locally applied instead of saline[37] Both saline and methylprednisolone acetate were administered using the same technique and at the same volume to ensure consistency across the two groups. The surgeons were unaware of the specific treatment being applied during the procedure. The clinical staff assessing the time to ambulation were aslos blinded to the group allocations. The blinding was maintained until the completion of data collection and statistical analysis, at which point the treatment codes were revealed for interpretation.

Interventions

Anaesthesia

For diagnostic imaging and surgery, dogs were premedicated with either butorphanol (0.2 mg/kg intramuscular [IM]) or methadone (0.2 mg/kg IM) in combination with either acepromazine (0.005–0.03 mg/kg IM or intravenous [IV]) or medetomidine (0.002–0.010 mg/kg IM or IV) prior to induction of anaesthesia. An 18 or 20 G IV catheter was placed in the cephalic or saphenous vein. Anaesthesia was induced using IV propofol (10 mg/mL), given to effect (1–10 mg/kg). All dogs were then intubated and anaesthesia was maintained with isoflurane to effect with a vaporiser setting starting with 1.0%–1.6% (concentration) in 100 mL/kg/min (volume) flow of oxygen and medical air with an inspired fraction of oxygen of 60%. Vaporiser settings were adjusted depending on the depth of anaesthesia (0.8–1.2 Minimum Alveolar Concentration (MAC)). End-tidal concentration of isoflurane, heart rate, non-invasive mean blood pressure, peripheral oxygen saturation end-tidal partial pressure of carbon dioxide and esophageal temperature were monitored constantly. An IV crystalloid solution (Ringer's acetate) was given at 5 mL/kg/h.

Surgical techniques

Surgeries were performed by a board-certified neurologist (F.S. and L.G.) or surgery resident (P.N.). For mini-hemilaminectomy, dogs were positioned in 30°–40° sternal oblique recumbency with the diseased side up on a tilting surgery table. A dorsolateral approach to the spine was performed at the affected site. The area around the intervertebral foramen and adjacent pedicles was freed bluntly from the surrounding musculature, and the tendinous attachment of the longissimus muscle to the accessory process at the affected site was severed. Mini-hemilaminectomy was performed using a high-speed burr (Stryker), followed by power-assisted fenestration of the affected disc in all cases.

After mini-hemilaminectomy, the dorsal and ventral spinal nerve roots were freed from their soft tissue surroundings, and the bone window was enlarged in the cranial, caudal and medial directions using the high-speed burr or Kerrison rongeurs.[38,39] Extruded disc material was carefully removed from the vertebral canal using fine rongeurs or probes.

The dogs' postoperative neurological status was evaluated daily by blinded clinical staff. Manual bladder expression was performed three to four times daily for dogs with difficulty urinating until the dog regained voluntary urination. Postoperative care involved a hospital stay until independent ambulation was observed and analgesia (NSAIDs and opioids). No systemic corticosteroids were administered postoperatively. The patients were routinely discharged from the hospital after they performed voluntary urination and independent ambulation (10 independent steps), as observed and documented by the clinical staff. This also marked the endpoint of the study. Dogs were discharged with NSAIDs (carprofen 2–4 mg/kg orally one to two times daily or robenacoxib 1 mg/kg daily) and tramadol (in selected cases) (2–5 mg/kg orally three times daily) for analgesia. No antibiotics were administered either preoperatively or postoperatively for any of the patients in this study. Home care instructions were provided to all owners, recommending the dog be restricted from exercise with brief leashed walks outside until the 2-week recheck and immediate start of physiotherapy and supported walks on a non-slippery floor. Jumping, playing and running were prohibited in the immediate postoperative period. Wound assessment and skin suture removal were routinely performed 10–14 days after the surgery. Potential complications or adverse events were monitored for 6 months after surgery. We defined postoperative complications as any adverse events occurring within the first 6 months after surgery, including but not limited to surgical site infection (SSI), delayed wound healing, worsening of neurological deficits and cystitis. These were systematically recorded and monitored through scheduled follow-up visits at our clinic. In cases where a follow-up visit was not possible, telephonic communication with the owner and referring veterinarian was used to gather information on a patient's postoperative status.

Outcome measures

The time to ambulation in days, counted from the day of surgical decompression, was documented and then statistically analysed. Ambulation was defined as the ability of the dog to perform 10 independent steps involving both hindlimbs.[40] Any observed complications and other epidemiological parameters, such as breed, bodyweight (kg), age (months) and sex, were also documented. The duration from the onset of clinical signs to the initiation of treatment was recorded for all dogs. This time interval was used to assess the uniformity of the study population in terms of the timing of intervention.

Statistical analysis

To investigate the effect of methylprednisolone acetate, bodyweight and age on the time to ambulation following surgical decompression, a multiple regression model was considered. Using the G*Power computer program for power analysis, it was determined that to observe a large effect size ($f^2 = 0.30$) with an 80% power level and an alpha level set at 0.05, a total sample of 41 dogs would be necessary.

For statistical analysis, first, an assessment was conducted on the data to determine whether the data and the residual of the data followed a normal distribution and equal variance. This assessment was carried out using the Shapiro–Wilk test and quantile–quantile (q–q) plot. The outcome data and the residual were not normally distributed. The parameters bodyweight, age and treatment option (saline or methylprednisolone acetate applied locally after decompression) were evaluated for their potential influences on the ambulation time after surgery using quantile regression.[41] Four regression models were built and the parameter beta (β) and 95% confidence interval (CI) were calculated at the mean (ordinal least squares), 25% quantile, 50% quantile (median) and 75% quantile for comparison.[42] For all analyses conducted, a p-value of less than 0.05 was deemed statistically significant.

RESULTS

A total of 41 dogs weighing 3–25 kg (median = 9 kg) were included. The most common breeds were French Bulldog (13 dogs), mixed breed (seven dogs), Bolonka (four dogs) and Dachshund (two dogs). The remaining dogs belonged to various other breeds, including one of each Yorkshire Terrier, Toy Poodle, Pekingese, Pug, Bichon Frise, Tibetan-Spaniel, Maltese, Jack Russell Terrier, Havanese, Berger des Pyrénées, Chihuahua and Coton de Tuléar.

Of the 41 included dogs, 24 were male (seven entire and 17 castrated) and 17 were female (all spayed). The median age of the dogs was 63 months (range 27.6–156 months).

The control group consisted of 23 dogs, of which 13 were male (three entire and 10 castrated) and 10 were female (all spayed). The most frequent breeds in this group were French Bulldogs (eight dogs) and mixed breeds (five dogs), with other breeds represented in smaller numbers. The median age in the control group was 67 months, with a range of 36–156 months.

The treatment group included 18 dogs, of which 11 were male (four entire and seven castrated) and seven were female (all spayed). French Bulldogs (five dogs) were the most common breed in this group. Other breeds included Toy Poodle, mixed breed, Yorkshire Terrier, Thibet-Spaniel, Maltese, Jack Russel/Bolonka mix, Havanese, Dachshund, Coton de Tuléar and Chihuahua. The median age in the treatment group was 60 months, with a range of 27–132 months.

The most frequently observed locations of IVDE included Th13-L1 ($n = 7$), L1-2 ($n = 6$), Th12-13 ($n = 5$) and L3-4 ($n = 4$). Th12-L1, L2-3 and L4-5 segments were affected in two cases each. Segments Th10-Th11, Th11-12 and Th11-13 were affected in one case each.

In the control group, the median number of days from onset of clinical signs to the initiation of treatment was 1 day, with a range of 1–5 days. In the treatment group, the median number of days from onset to treatment was 2 days, with a range of 1–4 days.

The median number of days for dogs in the control group to achieve ambulation was 7 days, with a range of 1–17 days, while dogs in the treatment group achieved ambulation in a median of 3 days, with a range of 1–8 days (Figure 1).

Quantile regression was employed to assess the impact of three parameters—bodyweight, age and treatment option—on ambulation time. The analysis revealed that dogs in the treatment group achieved a median ambulation time of 4 days quicker than dogs in the control group ($p = 0.01$). When examining dogs with shorter recovery times (QR 25%: ambulation <2 days) and longer recovery times (QR 75%: ambulation >8 days) separately, those in the treatment group also exhibited significantly shorter recovery times than the control group (2 days [$p = 0.05$] and 7 days [$p < 0.01$], respectively). Notably, bodyweight did not have a significant effect on recovery time. However, age demonstrated a significant effect ($p = 0.01$) on recovery time for dogs in the shorter recovery time quartile (QR 25%), with no significant effect observed for all other quantiles (Table 1).

A 10-year-old male neutered Berger des Pyrénées developed discospondylitis and abscess formation 3 weeks after surgery and epidural methylprednisolone application. After surgical treatment at L1/2, the dog regained ambulation after 3 days. Three weeks after discharge, the dog deteriorated again and became non-ambulatory paraparetic within 3 days. Follow-up MRI revealed abscess formation and discospondylitis at the level of the initial site of surgery. Further surgery was performed, and the abscess, including soft tissues, was removed. Because the infected segment was considered unstable, vertebral stabilisation using vertebral screws and polymethyl methacrylate was performed contralateral to the initial approach. *Staphylococcus aureus* and *Streptococcus dygalactidae* were cultured from the infected site, and the dog was treated with systemic amoxicillin and clavulanic acid (clavaseptin 20 mg/kg twice daily). The dog subsequently regained ambulation within 2 weeks. This case represents 2.4% of the entire study population and 6% of the treatment group. No other adverse events were reported among the remaining population.

DISCUSSION

The primary finding of our study is that non-ambulatory dogs with thoracolumbar intervertebral disc disease that received surgical decompression

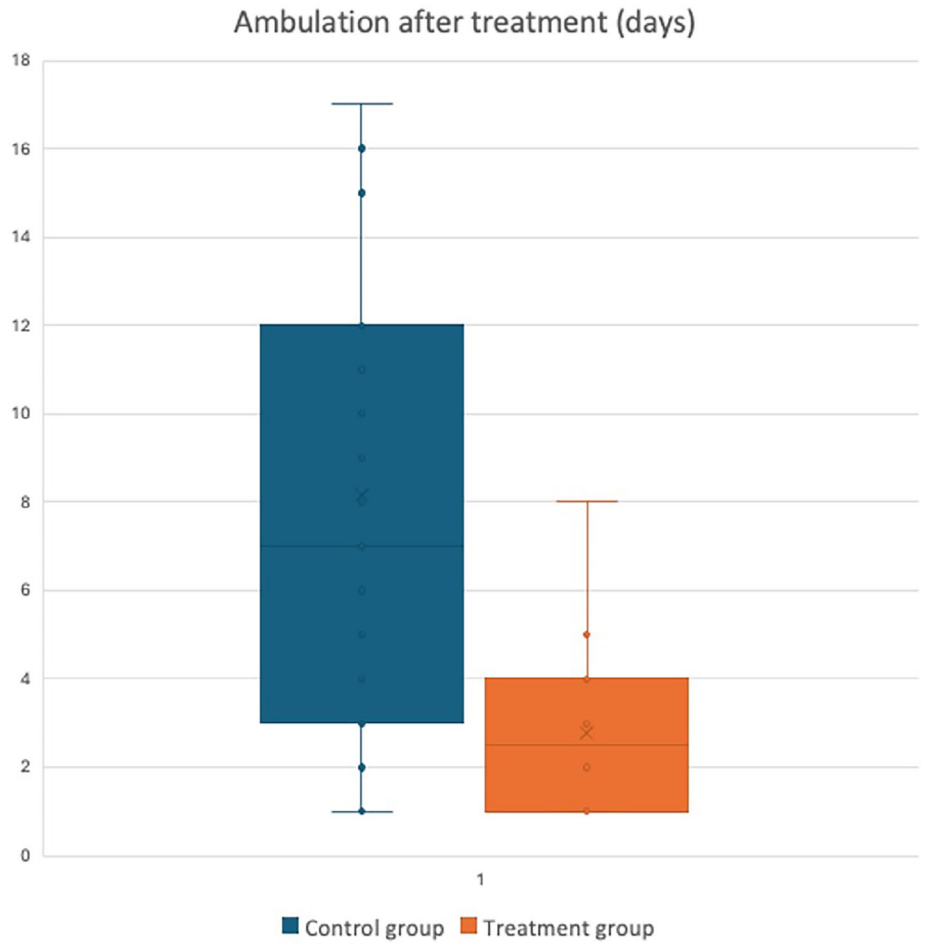

FIGURE 1 Time to ambulation for the control and treatment groups. The control group, shown in blue, required a median of 7 days to achieve ambulation, with a range of 1–17 days. Meanwhile, the treatment group, shown in orange, required a median of 3 days, with a range of 1–8 days

and local application of methylprednisolone acetate achieved ambulation in fewer days compared to the control group. The control group regained ambulation within a median of 7 days, with a range of 1–17 days. In contrast, the methylprednisolone acetate treatment group regained ambulation within a median of 3 days, with a range of 1–8 days. These results suggest that the anti-inflammatory properties of methylprednisolone acetate may play a beneficial role in spinal cord conduction after decompression.

Further investigation into the impact of methylprednisolone acetate on the dogs' mobility revealed nuanced findings. Dogs treated with methylprednisolone acetate exhibited variable reductions in recovery time: a modest 2-day improvement in the shorter recovery time quartile (25%) and a more significant 7-day improvement in the longer recovery time quartile (75%) relative to controls. This trend implies that the treatment might be more advantageous for dogs that potentially need longer recovery times, although such conclusions warrant cautious interpretation. Age also appeared to influence recovery among dogs with shorter recovery times, suggesting a faster recuperation in younger dogs. This effect of age seems to be relevant only within the first 2 days of recovery, as its significance diminishes beyond this timeframe. These results should be viewed again with caution, and further research is needed to confirm these observations and fully understand the treatment's efficacy and the role of age on recovery.

Our study documented a single case of discospondylitis and abscess formation at the surgical site. The rates of SSIs vary depending on numerous factors, including the type of surgery and the preventive measures employed. Because steroids are immunosuppressive they represent one of those risk factors.[43] This incident underscores a specific concern within the context of a low overall postoperative complication rate—2.4% for the entire study population and 6% for the treatment group. This rate is in close alignment with the 2.2% prevalence reported by Canal et al. but may indeed represent a higher risk if epidural steroids are applied.[44] The pathogenesis of SSIs after spinal surgery is multifactorial, categorised into patient factors and surgical and microbiological factors.[45] In human studies, advanced age, immunosuppression, spinal trauma and diabetes mellitus are established non-modifiable risk factors for SSIs.[45–47] In a recent study in veterinary medicine, bodyweight exceeding 20 kg was identified as a potential risk factor in univariate analysis.[44] In a study involving 513 dogs with discospondylitis, those over 10 years

TABLE 1 Quantile regression analysis summary

	OLS			QR 25%			QR 50% (median)			QR 75%		
Parameters	***β***	**95% CI**	***p*-value**	***β***	**95% CI**	***p*-value**	***β***	**95% CI**	***p*-value**	***β***	**95% CI**	***p*-value**
Bodyweight	−0.072	−0.369–0.225	0.62	−0.047	−0.279–0.186	0.69	−0.136	−0.464–0.192	0.40	−0.057	−0.535–0.422	0.81
Age (year)	0.038	−0.007–0.084	0.09	0.551	0.124–0.979	**0.01**	0.469	−0.134–1.072	0.12	0.555	−0.324–1.435	0.21
Treatment option	−5.198	−7.882—2.514	**<0.01**	−2.101	−4.205–0.004	**0.05**	−3.946	−6.912—0.979	**0.01**	−7.377	−11.706—3.048	**<0.01**

Abbreviations: CI, Confidence interval; OLS, ordinary least squares; QR, quartile regression.

of age had the highest odds of disease, possibly due to comorbidities, immunocompromised states or impaired healing processes.[48] Likewise, our practice of maintaining IV catheters for more than 24 hours after surgery may also have increased the risk for SSI. Although this isolated case does not allow general conclusions on adverse reactions to topical steroids, it certainly highlights the importance of monitoring the risks of local use of steroids and suggests that vigilance is crucial in monitoring and managing postoperative complications, especially in cases involving immunosuppressive treatments such as steroids. Also, the case raises the question of whether prophylactic antibiotics should be administered. In the context of spinal surgery, SSI remains a significant concern, and the risk may be increased with the epidural application of steroids.

The systemic application of corticosteroids for treatment of IVDD has historically been a controversial topic, and clinical efficacy and safety have been heavily disputed.[49,50] Although widely used for many years as a standard treatment for acute SCI in human medicine, the most recent studies show that systemically applied MPSS failed to provide a statistically significant short- or long-term improvement in patients' overall motor or neurological scores compared to controls that did not receive steroids.[51–54] Similarly, in the veterinary literature, studies have shown no significant difference in recovery rates between MPSS treatment and decompressive surgery alone,[17,18] perioperative use of NSAID,[19] polyethylene glycol,[20] a 21-aminosteroid (U74389G)[21] and placebo treatment.[20,21] A systematic review carried out for the Cochrane Database[55] focusing on corticosteroid application in patients with lower back pain with or without radiculopathy and in patients with vertebral stenosis (either acute, subacute or chronic) showed a marginal improvement in the steroids group than other treatment/placebo groups in regards to pain sensation improvement; however, a similar marginal effect was not observed in the vertebral stenosis group. Furthermore, the same review panel pointed out that no major side effects were observed that would definitively ban the clinical use of systemic corticosteroids.[55] Furthermore, Canseco et al. observed that possible delivery of systemic dexamethasone in SCI might be improved after performing decompressive laminectomy and durotomy.[56] Potential benefits such as reducing oedema and inflammation have been shown in experimental studies; however, the adverse effects associated with high-dose methylprednisolone, including increased risk of infections and gastrointestinal complications, necessitate a careful evaluation of its risk–benefit profile in the management of acute SCI.[57,58]

An IVDE results in mechanical compression and secondary injury of spinal cord tissue. This stimulates the inflammatory cascade, ranging from acute neutrophil invasion to the formation of chronic granulation tissue.[13] SCI remains a critically important topic within both human and animal model research.[15] The

hallmark of the SCI-associated inflammatory cascade includes the production of inflammatory molecules such as tumour necrosis factor, interleukin (IL)-1β and IL-6. This has been documented in both experimental rat models[32] and naturally occurring cases in dogs.[59] Notably, the administration of MPSS has been shown to inhibit this production, highlighting its potential therapeutic role.[32] IVDD-associated SCI triggers inflammation within the spinal cord, resulting in secondary damage.[3,13,60] Interestingly, a statistically significant inverse correlation has been observed between the degree of inflammation and the ability of dogs to regain ambulation.[13] This suggests that the severity of the inflammatory response may play a role in the overall prognosis and functional recovery of affected individuals. Hence, local application of steroids can potentially exert its therapeutic effects by means of mitigating the inflammatory response.[61–65] Anti-inflammatory treatments enhance locomotor recovery post-SCI by reducing inflammation, which has been shown to obstruct signal transmission at the injury site in mice, potentially through cytokine release.[16] Studies conducted in rats have demonstrated that epidural dexamethasone can decrease inflammatory hyperalgesia and spinal cytosolic phospholipase A2 expression, suggesting its potential to modulate inflammatory processes within the spinal cord, thereby contributing to enhanced locomotor recovery.[66] Epidural steroid injection has been shown to be effective in managing signs of lower back pain resulting from lumbar disc herniation in human patients, albeit with an ongoing debate regarding its overall impact.[67,68] No instances of minor or major adverse events were reported in the short-term follow-up period following the administration of local steroid infiltration in these studies. Therefore, it may be deduced that using local steroids could lessen inflammation and decrease pain for individuals, yet the information on epidural steroid injections for lower back pain, focusing primarily on local pain control, may not be entirely pertinent or adequate, as it does not address the reduction or reversal of intramedullary damage.

Several retrospective and prospective studies investigating neurological outcome and its correlation with the timing of surgical intervention suggested that prompt and timely administration of surgical treatment has positive effects on clinical outcomes, while other studies failed to support these findings.[5,69–73] In the present study, the median duration from the onset of clinical signs to the initiation of treatment was 1 day (range 1–5 days) in the control group and 2 days (range 1–4 days) in the treatment group. Hence, the study population was uniform in terms of the time interval between the onset of clinical signs and the initiation of treatment.

One potential limitation of the study was the inclusion of dogs from a heterogeneous population of clinical cases, with varying breeds, ages and health conditions. However, quantile regression was chosen for its robustness against population heterogeneity, data skewness and the influence of outliers, as it provides a suitable method to compensate for these challenges.[42] Another limitation identified in our research is the exclusion of onset speed data, which is attributable to difficulties in consistently tracking this information from pet owners and referring veterinarians. This challenge arises from variability in assessments and the complexities associated with accurately determining precise onset times for all subjects. The present observational clinical study lacks measurements of serum biomarkers for spinal cord trauma, notably glial fibrillary acidic protein and phosphorylated neurofilament heavy chain (pNF[H]), which may indicate lesion severity, as reported previously.[74–76] The incorporation of these biomarkers into future studies is warranted but is contingent upon the commercial availability of specific tests and the establishment of universally accepted reference ranges, particularly for pNF(H), that accurately reflect the variability associated with different aetiologies and severities of SCIs. The present study is constrained by a small sample size. We focused our evaluation on a limited set of parameters—bodyweight, age and treatment option. While it is recognised that there are additional parameters that may influence time to ambulation, our study prioritised these factors as they were deemed to be the most significant for evaluation. Incorporating multidimensional outcome measures, such as pain scores, in subsequent research is essential for a holistic evaluation of recovery processes in future studies.

In conclusion, our study suggests that local application of methylprednisolone acetate in combination with surgical decompression may lead to faster ambulation in non-ambulatory dogs with thoracolumbar intervertebral disc disease. The anti-inflammatory properties of steroids may play a role in mitigating the inflammatory response and promoting faster recovery of spinal cord conduction. One dog from the treatment group in our study developed discospondylitis as a postoperative complication. Further studies with a more homogeneous population and considering other prognostic factors are needed to validate the findings of the study.

AUTHOR CONTRIBUTIONS

Concept and design of the study, data acquisition, performed surgeries, involved in data collection, analysis and interpretation, drafted the manuscript, revised the manuscript and approved the submitted version of the manuscript: Pavlos Natsios. *Data acquisition, performed surgeries, involved in data collection, drafted the manuscript and revised and approved manuscript*: Lorenzo Golini. *Study design, performed data analysis and interpretation, including the statistical data analysis, revised the manuscript drafts critically and approved the submitted version of the manuscript*: Brian H. Park. *Concept and design of the study, provided essential scientific input, data acquisition, performed surgeries, involved in the interpretation of the acquired data, revised the manuscript drafts critically*

and approved the submitted version of the manuscript: Frank Steffen.

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CONFLICT OF INTEREST STATEMENT

None of the authors of this article has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The study was approved by the Swiss National, Cantonal and Institutional Animal Care and Use Committees (approval number: ZH172/2022).

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