Lumbosacral intervertebral disk extrusions in 13 dogs

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Abstract

Objective: To describe the clinical presentation, magnetic resonance imaging (MRI) findings, and outcome of dogs treated surgically for lumbosacral intervertebral disk extrusion (IVDE).

Study Design: Retrospective study.

Animals: Thirteen dogs.

Methods: Records and MRI studies of dogs with intraoperatively confirmed lumbosacral IVDE were reviewed. MRI features of thoracolumbar IVDE were applied to all cases. Postoperative outcome was subjectively assessed as excellent, good, or poor.

Results: All dogs had an acute or subacute onset of lumbosacral pain and nerve root signature. Seven dogs had neurological deficits. MRI revealed lateralized herniated disk material and partial to complete disk degeneration in all cases; the extradural material extended cranial and/or caudally from the disk space in 10 cases. All dogs underwent L7-S1 dorsal laminectomy and removal of extruded disk material. In six dogs, surgery was complicated by inflammatory changes, including one case of epidural steatitis. On reexamination 4–6 weeks post-surgery, outcome was judged as excellent in 11 dogs and poor in the remaining 2 due to contralateral nerve root signature in one case and nonambulatory paraparesis and urinary incontinence in the case with steatitis.

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**Conclusion:** Lumbosacral IVDE in dogs was characterized by acute/subacute onset of lumbosacral pain and nerve root signature and lateralized and often dispersed extradural material over a degenerated L7-S1 intervertebral disk on MRI. Early decompressive dorsal laminectomy generally resulted in excellent clinical outcome.

**Clinical Significance:** Observation of these clinical and imaging features in dogs should prompt clinical suspicion of lumbosacral IVDE.

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1 | **INTRODUCTION**

Intervertebral disk herniation (IVDH) was first described by Hansen in 1950 and is one of the most common neurological disorders in dogs, affecting approximately 2% of cases presented to referral hospitals.1-3 Hansen classified intervertebral disk extrusion (IVDE) as type I disk disease and intervertebral disk protrusion (IVDP) as type II disk herniation. IVDE is typically associated with chondroid degeneration and involves herniation of nucleus pulposus through a fully ruptured annulus fibrosus. In contrast, IVDP results from fibroid degeneration and is characterized by a gradual and focal extension of the annulus fibrosus and dorsal longitudinal ligament into the vertebral canal.1,4 Intervertebral disk protrusions generally affect older dogs, whereas IVDEs tend to be more acute and can occur in younger dogs.5 Both types of herniations affect nonchondrodystrophic dogs, whereas chondrodystrophic dogs are more frequently diagnosed with IVDE.4,6 Treatment recommendations and even prognoses also differ between thoracolumbar IVDE and IVDP.5,7 Consequently, magnetic resonance imaging (MRI) parameters have recently been developed to differentiate thoracolumbar IVDE from IVDP in dogs.5,8 Preoperative differentiation between types of IVDH can help guide treatment but is also meant to improve our knowledge about the natural history of disease and outcome after medical management.

IVDP is the most commonly encountered type of IVDH in the lumbosacral junction, usually contributing to degenerative lumbosacral stenosis (DLSS).6,9 Lumbosacral pain is the most common clinical finding in dogs with DLSS, although pelvic limb weakness, nerve root signature, difficulty rising or lying down, tail paresis, and urinary or fecal incontinence may also be present. Neurological deficits are not always present or easily detected, and clinical course can be protracted.10-13 MRI abnormalities associated with DLSS include midline or concentric bulging of L7-S1 disk centered over its intervertebral space, attenuation of the epidural fat on T1-weighted images, and loss of the nucleus pulposus water signal on T2-weighted images.9,10 Medical treatment has been reported to be successful in about 55% of dogs with DLSS. Satisfactory outcomes have been described in 77–93% of dogs after dorsal laminectomy (with or without concurrent dorsal annulectomy and/or foraminotomy), 76–85% of dogs treated with dorsal laminectomy and transarticular screw fixation, and 95–100% of dogs undergoing lateral foraminotomy alone or combined with dorsal laminectomy.11,12,14-21

Conversely, IVDE generally affects the cervical and thoracolumbar spine. In fact, the probability of an IVDE at L7-S1 intervertebral disk space is 31.4 times lower than that of an IVDP.6 As a result, lumbosacral IVDE is rarely described, affecting the ability to provide evidence-based care.10,22,23 The aim of this retrospective study was to report preoperative findings and outcomes after decompressive dorsal laminectomy.

2 | **MATERIALS AND METHODS**

Medical records and corresponding MRI studies of dogs with intraoperatively confirmed lumbosacral IVDE that were presented to two referral hospitals between 2011 and 2018 were reviewed. Ethical approval of the study was provided by the Research Ethics Committee of the School of Veterinary Medicine of the University of Glasgow (Ref18a/17). IVDE was diagnosed when disk material with a loose chalky or liquid consistency was found in the vertebral canal.24 Furthermore, histopathological confirmation of IVDE was recorded when available. Dogs were included if a minimum follow up of 4 weeks was available. Dogs with incomplete clinical records or MRI studies or those found to have a firm, annular protrusion at surgery were excluded.

Data collected from medical records included signalment, onset and duration of presenting clinical signs; treatment prior to referral; physical and neurological examination results; surgical findings; and minimum follow-up information of 4 weeks postoperatively. Onset of signs was classified as acute (within 48 hours), subacute (within 2–7 days), or chronic (more than 7 days) based on the client-provided history.25,26 Duration of signs was defined as the number of days from the client-reported onset to presentation. Presence of lumbosacral pain, nerve root signature (defined as referred pain down a limb, causing
lameness or elevation of the limb), and neurological deficits was recorded.27 Neurological deficits were defined as one or more of the following: paresis; proprioceptive deficits; reduced or absent pelvic limb spinal reflexes; perineal reflex or tail tone; reduced nociception in the pelvic limbs, perineal region, or tail; and fecal or urinary incontinence.

2.1 | Magnetic resonance imaging

Magnetic resonance images were obtained under general anesthesia with two different 1.5-Tesla magnets (Signa 1.5 MRI system, GE Healthcare, Buckinghamshire, UK and Magnetom Essenza 1.5 MRI, Siemens AG, Erlangen, Germany). Transverse, sagittal, and dorsal T2-weighted sequences were acquired in all cases, and transverse T1-weighted images were obtained in all cases but one. T1-weighted images after IV administration of gadopentate dimeglumine (Magnevist, Bayer Schering Pharma AG, Berlin, Germany) were also evaluated in six dogs. All imaging studies were reviewed by a board-certified veterinary neurologist (RJL) and assessed for MRI variables previously proposed as independent predictors for the type of IVDH by Gomes et al.5 and validated by De Decker et al.8 These variables included: lateralization of the herniated disk material, location of herniated disk material relative to the intervertebral disk space, and degree of intervertebral disk degeneration. Lateralization of the herniated disk material was assessed on T1- and T2-weighted transverse images and was classified as being exclusively in the midline or lateralized. Craniocaudal extension of intervertebral disk material was assessed on T2-weighted sagittal images and defined as confined to the intervertebral disk space or dispersed (intervertebral disk material extending beyond the limits of the disk space or associated vertebral endplates). Assessment of intervertebral disk degeneration was based on the signal of the nucleus pulposus on T2-weighted sagittal images. Grade 0 was given to a nondegenerate intervertebral disk with a homogenous hyperintense signal; grade 1 was used for partially degenerate intervertebral disks and defined as heterogeneous loss of hyperintense signal; and completely degenerate intervertebral disks with complete loss of hyperintense signal were considered grade 2.5,8 T1- and T2-weighted MRI signal intensity of the extradural disk material and degree of contrast enhancement, where available, were also noted.

2.2 | Surgical treatment

Dorsal laminectomies of L7 and S1 were performed by a board-certified veterinary surgeon or neurologist after standard dorsal approach in all dogs. Dorsal fenestration of the L7-S1 disk consisting of dorsal annulectomy and nuclear pulpectomy9 was implemented at the discretion of the surgeon. Surgical reports were reviewed for confirmation of the type of intervertebral disk herniation. Clearly noted observation of disk material of a chalky or liquid consistency without physical connection with the ruptured annulus fibrosus was required for inclusion. Documented intraoperative complications were noted, as was the presence of epidural hemorrhage. Histopathological analysis findings, where available, were also reviewed. Neurological examination findings and prescribed medications at discharge were recorded. Owners of all included dogs were instructed to crate rest them for 4–6 weeks.

2.3 | Outcomes

Dogs were examined at the respective referral center 4–6 weeks after surgery.11,12,21 Information on follow-up neurological examination findings was reviewed. In addition, long-term follow up (defined as ≥4 months) was obtained from the clinical records of the referring veterinarian when available.11 Postoperative outcome was defined as excellent if there was complete resolution of clinical signs and good if a substantial improvement in clinical signs was achieved.12 Improvement was considered substantial when all preoperative signs were resolved, but the dog still had occasional mild signs of lumbosacral pain or pelvic limb weakness/lameness. Outcome was considered poor if the dog did not improve, deteriorated, or experienced a recurrence within the short-term follow-up period. Data were reported as medians, means, and range.

3 | RESULTS

The 13 dogs included in the study consisted of eight males and five females. Median age at presentation was 7.3 years (mean: 7.1, range 3.5–10 years), and the median body weight was 24.7 kg (mean: 23.5 kg, range 5–40 kg). Eight dogs were nonchondrodystrophic, including three Labrador Retrievers, two Siberian Huskies, one Staffordshire Bull Terrier, one Weimaraner, and one German Shepherd Dog. Five dogs were chondrodystrophic, including one each of the following breeds: English Cocker Spaniel, Standard Dachshund, Cavalier King Charles Spaniel, Lhasa Apso, and Miniature Poodle.

Time between onset of clinical signs and presentation ranged between less than 1 and 46 days (median: 12 days, mean: 15 days). Nine dogs were presented with an acute
| Dog | Breed/age (years)/sex | Neurologic status at presentation<sup>a,b,c</sup>/ onset/duration of signs (days) | MRI IVDE location within vertebral canal/ respective to IVD space/ IVD degeneration grade | Intraoperative complications<sup>d</sup>/days from onset to surgery | Neurologic status at discharge postsurgery<sup>a,b</sup> (day) | Short-term outcome (days postsurgery) | Long-term outcome (months postsurgery) |
|-----|----------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------------|----------------------------------------|
| 1   | LR/6.9/FN            | Paraparesis, decreased RPL flexor reflex, reduced tail tone/Acute/13            | Right-lateralized/ Confined/1                                                      | No/14                                                                           | Normal (3)                                                                      | Excellent (41)                        | N/A                                    |
| 2   | SD/9.3/MN            | Decreased proprioception and RPL flexor reflex/ Subacute/7                     | Right-lateralized/ Dispersed/2                                                    | Yes/8                                                                           | RPL paresis (3)                                                                | Excellent (36)                        | Excellent (8)                          |
| 3   | BT/6.8/M             | Absent proprioception/ Acute/2                                                 | Right-lateralized/ Dispersed/2                                                    | No/2                                                                            | Decreased proprioception RPL (3)                                               | Excellent (30)                        | N/A                                    |
| 4   | W/4/MN               | Decreased proprioception RPL/Acute/27                                          | Left-lateralized/ Dispersed/1                                                     | No/28                                                                          | Normal (4)                                                                     | Excellent (40)                        | Excellent (17)                         |
| 5   | GSD/10/MN            | Paraparesis, decreased proprioception/ Subacute/4                              | Left-lateralized/ Dispersed/1                                                     | Yes/14                                                                          | Pain, nonambulatory paraparesis, decreased flexor reflexes, reduced tail tone and urinary incontinence (11) | Poor (29)                            | Poor (4)                               |
| 6   | SH/3.5/F             | Absent deficits/ Subacute/12                                                    | Right-lateralized/ Confined/1                                                      | No/13                                                                           | Normal (3)                                                                     | Excellent (25)                        | Excellent (24)                         |
| 7   | ECS/4.5/MN           | Absent deficits/ Subacute/21                                                    | Right-lateralized/ Dispersed/2                                                    | Yes/27                                                                          | Normal (4)                                                                     | Excellent (38)                        | Excellent (67)                         |
| 8   | LR/9/F               | RPL paresis, reduced tail tone, reduced perianal reflex/ Acute/46              | Right-lateralized/ Dispersed/2                                                    | Yes/47                                                                          | LPL nerve root signature (5)                                                    | Poor (27)                            | Good (21)                              |
| 9   | LR/8.9/FN            | Absent deficits/Acute/4                                                         | Left-lateralized/ Dispersed/1                                                     | Yes/4                                                                           | Normal (2)                                                                     | Excellent (32)                        | Excellent (35)                         |
| 10  | SH/4.8/FN            | Absent deficits/ Acute/<1                                                       | Left-lateralized/ Dispersed/1                                                     | No/2                                                                            | Normal (1)                                                                     | Excellent (40)                        | N/A                                    |
| 11  | CKCS/8.8/M           | Decreased proprioception LPL/Acute/21                                          | Right-lateralized/ Confined/1                                                     | Yes/43                                                                          | Decreased proprioception LPL (2)                                               | Excellent (28)                        | Excellent (28)                         |
| 12  | LA/8/MN              | Absent deficits/ Acute/7                                                        | Right-lateralized/ Dispersed/2                                                    | No/8                                                                            | Normal (2)                                                                     | Excellent (45)                        | Excellent (15)                         |
onset of pain in the lower lumbar region and reluctance to exercise, whereas four experienced a subacute onset of the same signs. All dogs had been medically managed by the referring veterinarian with different combinations of opioids, gabapentin, and nonsteroidal anti-inflammatory drugs or corticosteroids. Nine dogs improved before reoccurrence of similar signs, three experienced an incomplete response, and one failed to respond to treatment.

Neurological examination was consistent with a lesion on the L6-S3 spinal cord segments or nerves in all cases. Pain was found upon palpation of the lumbosacral spine and/or tail manipulation in all dogs. Signs consistent with nerve root signature were found in all dogs either uni- (12 cases) or bilaterally (dog #12). Seven dogs had neurological deficits (Table 1). When lateralized, clinical signs were ipsilateral to the side of the extradural lesion in all dogs but three (dogs #1, 10, 11) with contralateral signs.

Extradural material was identified on examination of MRI of the lumbosacral spine, located over the L7-S1 intervertebral disk space in all dogs (Figures 1 and 2). On T2-weighted images, the lesion was heterogeneously hyperintense to the spinal cord (Figure 1) or of mixed signal intensity in five dogs, respectively, hypointense in two dogs, and isointense in one dog. T1-weighted signal of the extradural material was isointense to the spinal cord in 8 of 12 dogs and heterogeneously hypointense or iso- to hyperintense in 2 other dogs each. T1-weighted images after administration of contrast were obtained in six dogs, consistent with mild to marked heterogeneous enhancement of the extradural material in three dogs (Figure 2), mild rim enhancement in two dogs, and no enhancement in the remaining dog. Nerve roots compressed by the extradural material took up contrast in five dogs (Figure 2(D)). In dog #5, a heterogeneously hyperintense signal of the epidural fat around the cauda equina over the L7-S1 vertebrae was observed on T1- and T2-weighted images along with a mild degree of enhancement after contrast administration, consistent with epidural steatitis.28 Lateralized disk material was observed in all dogs on transverse magnetic resonance images (Figures 1 and 2), four to the left and nine to the right side (Table 1). On sagittal T2-weighted images, extradural disk material was dispersed beyond the intervertebral disk space in 10 dogs (Figure 1). Disk degeneration was graded as 1 (partial) in eight dogs and 2 (complete) in the remaining five cases.

Time between onset of clinical signs and surgical procedure ranged from 2 to 47 days (median: 14 days, mean: 19 days). All dogs underwent L7-S1 dorsal laminectomy for removal of extruded disk material (Figure 3(A)), and fenestration of L7-S1 disk was performed in 10 dogs.
Epidural hemorrhage was observed in two dogs (#3 and #9). In six dogs, surgery was complicated by inflammatory changes causing associated severe nerve root thickening and/or adhesions between neural and surrounding tissues (Table 1), including dog #5 with histopathologically confirmed epidural steatitis (Figure 3(B) and (C)). Median time between onset of signs and surgery in dogs with reported complications was 21 days (mean: 24; range 4–47) and 13 days (mean: 15; range 2–41 days) in dogs without. Decompression seemed satisfactory in all dogs as assessed intraoperatively. Histopathological analysis of collected samples in four cases was consistent with degenerated fibrocartilaginous tissue (Figure 3(B)).

All dogs recovered uneventfully and were hospitalized for a median of 3 days (mean: 3 days, range 1–11 days). Eight dogs did not have discomfort or neurological abnormalities on neurological examination at discharge. Dog #5 had severe discomfort on palpation of the lumbosacral area along with nonambulatory paraparesis, decreased flexor reflexes in the pelvic limbs, reduced tail tone, and urinary incontinence. This dog presented with ambulatory paraparesis, pelvic limb proprioceptive deficits, nerve root signature on the left pelvic limb, and pain on palpation of the lumbosacral region (Table 1). Subsequent to MRI, the owner opted for medical management. However, the dog developed urinary and fecal incontinence, and surgery was therefore performed. The cauda equina appeared markedly swollen, and the nerve roots were attached together. The compressive material was removed from the vertebral canal, and histopathological examination results were compatible with degenerated extruded nucleus pulposus and acute neutrophilic inflammation (Figure 3(B) and (C)). After surgery, the dog experienced further deterioration and became nonambulatory. In the remaining four dogs (#2, #3, #8 and #11), only mild neurological deficits (Table 1) were reported. All dogs were discharged with gabapentin and different choices of nonsteroidal anti-inflammatory drugs plus recommendation for restricted exercise.

Dogs were reexamined approximately 4–6 weeks after surgery (mean: 34 days, median: 35, range 25–45 days). Outcome was graded as excellent in 11 dogs. Outcome was considered poor in dogs #5 and #8 due to nerve root signature on the contralateral limb at presentation in dog
and severe pain, nonambulatory paraparesis, and urinary incontinence in dog #5, in which epidural steatitis had been diagnosed. Of the 10 dogs treated with dorsal laminectomy and fenestration of L7-S1 intervertebral disk, 9 had an excellent outcome, and in 1 (#5), outcome was poor. In those for whom disk fenestration was not performed, outcome was excellent in two dogs (#1 and #12) and poor in one (dog #8).

Long-term follow-up information, obtained from clinical records of the referring veterinarian, was available for 10 dogs at 4–67 months (mean: 24; median: 21 months). Dog #5 was reported continent and ambulatory paraparetic with pain on palpation of the lumbosacral area 4 months after the surgical procedure. Dog #8 improved after medical management of the suspected relapse. Reoccurrence of any of the clinical signs was not reported in any dog during the follow-up period (Table 1).

4 | DISCUSSION

Canine lumbosacral disk disease is often associated with IVDP, but few reports have described IVDE of the L7-S1 disk in dogs.12,22,23 As a result, detailed information on clinical signs, MRI findings, and postoperative outcome is scarce. In this study, we describe 13 dogs with surgically confirmed lumbosacral IVDE.

Of these 13 dogs, 8 were nonchondrodystrophic, including some breeds reportedly predisposed to IVDE in the cervical and/or thoracolumbar vertebral column (i.e., Labrador Retriever, Siberian Husky, and German Shepherd Dog), and 5 were chondrodystrophic.1,7,29-31 Overrepresented breeds in studies of DLSS include German Shepherd Dogs, Golden and Labrador Retrievers, Dalmatians, and Border Collies, and affected dogs most commonly weigh over 25 kg.11,12,16,18-21 Our study provides evidence of IVDE in nonchondrodystrophic breeds, but a larger sample size would be required to test predisposition factors to lumbar-sacral IVDE.

The age of dogs (median 7.3 years) in our study is similar to that of dogs with DLSS, but the median duration of clinical signs (median 12 days) is considerably shorter than that reported in two previous studies on DLSS in dogs (62 and 92 days, respectively).11,12 Thus, a shorter duration of clinical signs could be more indicative of lumbosacral IVDE than IVDP in line with that described by Gomes et al.,5 who found that duration of clinical signs under 21 days was significantly associated with IVDE rather than IVDP in the thoracolumbar vertebral column.

The most common clinical presentation in this study consisted of acute or subacute onset of lumbosacral pain and nerve root signature (all cases). Two recent studies investigated the clinical signs of DLSS, and while lumbosacral pain was similarly reported as the most common clinical sign in 91% and 71% of dogs, respectively, nerve root signature was only described in 33% of the cases.11,12 In lumbosacral disk herniation in humans, lateral disk herniation is more commonly associated with radiating leg pain than medial disk herniation.32 An extruded disk tends to lateralize, irritate, or compress the exiting nerve root or dorsal root ganglion more directly than midline IVDPs.5 Extruded disk material was lateralized in all dogs included here, thereby explaining the higher incidence of nerve root signature in our population compared to recent reports on DLSS in dogs.11,12 Neurological deficits in the studied dogs with lumbosacral IVDE and their

FIGURE 3  Intraoperative view of dorsal L7-S1 laminectomy in dog #2 (A). Note the presence of chalky material consistent with extruded nucleus pulposus, elevating the right S1 spinal nerve roots dorsally and displacing the conus medullaris to the left. Microphotographs of biopsied extradural tissue in dog #5 (B and C): degenerate fibrocartilaginous tissue (B) is present with deposits of alcianophilic extracellular matrix (asterisk) and sparse neutrophils (arrows), consistent with acute changes associated with nucleus pulposus extrusion. Alcian blue/Periodic acid-Schiff stain; scale bar: 50 μm. (C) Area of prominent neovascularization and fibroblast proliferation (granulation tissue) with scattered hemorrhages and neutrophil infiltration. Hematoxylin and eosin stain; scale bar: 50 μm.
incidence, on the other hand, were similar to those described in DLSS.9-12 Signs contralateral to the extruded disk material have been reported to occur in 35% of dogs with thoracolumbar IVDE.33 Similarly, three dogs in our study had signs contralateral to the side of compression. Our findings prompt us to suggest that IVDE should be considered in the differential diagnosis of dogs with acute or subacute onset of lumbosacral pain and lateralized neurological signs, especially when nerve root signature is present.

MRI findings in most of the dogs included in this study consisted of T1-weighted isointense and T2-weighted mixed signal or heterogeneously hyperintense to the spinal cord extradural compressive material with varying degrees of heterogeneous diffuse or peripheral contrast enhancement. To date, only the T2-weighted MRI appearance of a lumbosacral IVDE in one dog has been described, consisting of hypointense left-lateralized extradural compressive material.22 On the other hand, T2-weighted heterogeneous to hyperintense and T1-weighted iso-intense signals were frequently observed in one report of dogs with confirmed thoracolumbar IVDE and epidural hemorrhage or inflammation.34 Interestingly, these findings were more common in IVDEs in the caudal aspect of the lumbar vertebral column. In addition, a similar pattern of contrast enhancement of the compressive extradural material observed in this study has been described in thoracolumbar IVDHs with significantly more frequent occurrence in IVDEs than IVDPs.34,35 MRI predictors of thoracolumbar IVDE were frequent in our study, mostly lateralization of the extradural disk material (all dogs) and dispersion of this beyond the boundaries of the intervertebral disk space (77%). These features may therefore help differentiate IVDE from IVDP at the lumbosacral junction.5,8 Conversely, completely degenerated intervertebral disk material, another MRI predictor of thoracolumbar IVDE, was only observed in five dogs (38%), whereas partial degeneration, more commonly associated with thoracolumbar IVDP, was noted in other dogs. Thus, larger studies including similar numbers of dogs with lumbosacral IVDE and IVDP are necessary to establish the value of these variables for differentiating types of lumbosacral IVDH. In summary, the presence of lateralized and dispersed, T2-weighted heterogeneous to hyperintense and T1-weighted isointense extradural material with diffuse or peripheral contrast enhancement over a partial or completely degenerated L7-S1 intervertebral disk on MRI should prompt IVDE as the main differential diagnosis in dogs.

Dorsal laminectomy resulted in successful cauda equina decompression, as assessed intraoperatively, in all 13 dogs. Excellent outcome without postoperative complications and resolution of presenting clinical signs was achieved in 11 of 13 dogs at short-term follow up. Fenestration of the affected disk was performed at the surgeon’s discretion in 10 dogs. One dog (#8) treated with dorsal laminectomy without fenestration was diagnosed with nerve root signature on the contralateral side on reexamination 4 weeks postoperatively. Further disk extrusion causing compression of the nerve roots was suspected. Unfortunately, follow-up MRI was declined by the owner, and supportive medical management was chosen instead. Although dorsal fenestration has been described as part of the surgical treatment for lumbosacral IVDP in dogs, its influence of postoperative outcomes is unknown.9,36 Surgery was complicated by nerve root swelling and/or adhesions in six dogs in this study, including a case of confirmed epidural steatitis. Thickening of the spinal nerves and adhesions with surrounding tissues was also reported to complicate surgery in English Cocker Spaniels with causal lumbar IVDE, including four with lumbosacral disease.23 Subsequently, delaying diagnosis and surgical treatment was proposed to initiate this cascade of morphological changes. In this study, median time from onset to surgery was longer in dogs with changes secondary to inflammation than in those without. However, while removal of chronically extruded material tends to be more difficult, larger studies are necessary to establish the influence of timing of treatment on this finding. Outcome after dorsal laminectomy for the treatment of DLSS with associated IVDP has been graded as excellent or good in 77–93% of dogs in previous studies.12,14-17 Our outcomes are consistent with these reports, with excellent outcomes in 11 of 13 dogs. A recent study on DLSS reported excellent or good outcomes in 55% of dogs managed medically, but such information is not available for dogs with lumbosacral IVDE.11

The limitations of this study are intrinsic to its retrospective nature, including the lack of a control group. Thus, further studies comparing surgical versus medical management in lumbosacral IVDE in dogs are necessary. The MRI data provided by this study, however, might facilitate the selection of cases for studies assessing medical management in this condition (i.e., without intraoperative confirmation).

In conclusion, this case series is the first to report the clinical signs, MRI features, and postoperative outcomes in dogs with lumbosacral IVDE. Although rare, this condition should be suspected in dogs with an acute/subacute onset of lumbosacral pain and nerve root signature and the presence of lateralized and dispersed extradural material over a partial or completely degenerated L7-S1 intervertebral disk on MRI. Finally, dorsal laminectomy was associated with an excellent prognosis in most dogs of this study.
AUTHOR CONTRIBUTIONS
Bresciani L., DVM, PGCert(sas): acquisition, analysis, and interpretation of data; drafting the article; revising it for intellectual content; and final approval of the completed article. Trevail R., DVM, Diplomate ECVN: acquisition, analysis, and interpretation of data; revising the article for intellectual content; and final approval of the completed article. Clarke S., BVMS, DSAS (Orth), Diplomate ECVS: conception of the study; acquisition, analysis and interpretation of data; revising the article for intellectual content; and final approval of the completed article. Gutierrez-Quintana R., MVZ, MVM, Diplomate ECVN: acquisition, analysis, and interpretation of data; revising the article for intellectual content; and final approval of the completed article. Behr S., DVM, Diplomate ECVN: acquisition, analysis, and interpretation of data; revising the article for intellectual content; and final approval of the completed article. Oxley B., MA, VetMB, DSAS (Orth): acquisition, analysis, and interpretation of data; revising the article for intellectual content; and final approval of the completed article. Pink J., BSc, BVetMed, CertSAS, Diplomate ECVS: acquisition, analysis, and interpretation of data; revising the article for intellectual content; and final approval of the completed article. José-López R., DVM, Diplomate ECVN: conception and design of the study; acquisition, analysis, and interpretation of data; drafting the article; revising it for intellectual content; and final approval of the completed article.

CONFLICT OF INTEREST
The authors declare no conflict of interest related to this report.

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