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Association of magnetic resonance assessed disc degeneration and late clinical recurrence in dogs treated surgically for thoracolumbar intervertebral disc extrusions

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Abstract

Background: Radiographic signs of intervertebral disc mineralization are thought to indicate sites of future recurrence of disc extrusion (Hansen type I) but the relationship between evidence of disc degeneration on magnetic resonance imaging (MRI) and future disc extrusion with recurrence of clinical signs has not been examined.

Objectives: To examine the relationship between MRI-assessed degeneration of thoracolumbar intervertebral discs and late recurrence of clinical signs in dogs presented with acute thoracolumbar intervertebral disc extrusion and treated by hemilaminectomy alone.

Animals: Ninety-two client-owned dogs presented to 2 referral hospitals between 2009 and 2014.

Methods: Retrospective analysis of association between clinical signs consistent with recurrent thoracolumbar intervertebral disc extrusion and MRI evidence of disc degeneration in dogs undergoing hemilaminectomy for acute thoracolumbar intervertebral disc extrusion. Univariable and multivariable Cox regression analyses were used to explore associations between recurrence of clinical signs and several characteristics of T10-L3 discs at initial diagnosis.

Results: Ninety-two cases were included, of which 42 (46%) were Dachshunds and median age was 5.3 years. Clinical signs recurred in 33/92 (36%) dogs. Finding a completely degenerate disc in the T10 to L3 region (in addition to the operated site) at the time of surgery was associated with a hazard ratio of 2.92 (95% confidence interval: 1.37-6.20) for recurrence of clinical signs.

Conclusions and clinical importance: Our results suggest that in cases of thoracolumbar intervertebral disc extrusion in dogs, recurrence of signs is likely if at least 1 completely degenerate disc in addition to the currently symptomatic disc is visible on MRI.

Abbreviations: IVD, intervertebral disc; IVDE, intervertebral disc extrusion; MRI, magnetic resonance imaging; TL, thoracolumbar; T2W, T2-weighted.

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KEYWORDS

chondrodystrophy, neuroimaging, neurology, neurosurgery

1 | INTRODUCTION

Thoracolumbar (TL) Hansen type I intervertebral disc extrusion (IVDE) is a common cause of spinal cord injury and neurological dysfunction in dogs.^{1,2} IVDE can be managed by either conservative or surgical means, with a recent meta-analysis suggesting that surgical management may be superior for dogs that become nonambulatory.³ After an episode of TL IVDE, clinical signs recur in 0% to 42% of dogs.⁴⁻⁹ Recurrence is typically divided into “early” recurrence, occurring within 4 to 6 weeks after surgery, and “late” recurrence, occurring months or even years after the initial surgery. Early recurrence is usually diagnosed at, or assumed to involve, the initially affected disc whereas late recurrence is caused by extrusion of another disc.⁶ Late recurrence most often affects an intervertebral disc (IVD) adjacent to that initially affected or adjacent to a fenestrated disc.^{2,6,7,9,10}

Functional recovery is reported to be as likely following repeat surgery as after the initial insult.^{2,6,9,11} Nevertheless, the need for reintervention can be onerous, can reduce owner compliance, and may even induce some owners to select euthanasia.¹⁰

Intervertebral disc fenestration is well-recognized to reduce the risk of future extrusion and recurrence of clinical signs.^{9,10,12,13} When prophylactic fenestration is performed alongside decompressive surgery, recurrence rates of 0% to 24% have been reported,^{4,8-10,14} with 1 study showing that prophylactic fenestration of 6 IVDs at the time of decompressive surgery rather than just the affected one reduces recurrence from 17% to 7%.¹⁰

Degeneration and calcification of the IVD is related to IVDE.^{1,15} Radiographically visible disc calcification, indicating complete degeneration, is a significant predictor of IVD herniation in Dachshunds¹⁶ and a risk factor for recurrent herniation after surgery.^{7,10} For this reason, fenestration of radiologically calcified IVDs adjacent to an active site is recommended at the time of decompressive surgery.¹⁰

Magnetic resonance imaging (MRI) is the gold standard imaging modality for detection and characterization of spinal cord injuries^{2,16-20} and allows earlier stages of disc degeneration to be identified compared with radiographs or computerized tomography, because changes can be identified before calcification occurs.²¹ It is reasonable to consider that other discs in the TL region already degenerated at the time of an initial IVDE would be more likely to go on to extrude and cause clinical signs of recurrence but there is no direct evidence to support this assumption.

The aim of this study was therefore to examine MRI evidence of disc degeneration of all IVDs between T10 and L3 in a population of dogs that underwent decompressive surgery for TL IVDE without concomitant prophylactic fenestration. We tested the hypothesis that the evidence of disc degeneration at other sites would lead to a higher incidence of late recurrence of clinical signs.

2 | MATERIALS AND METHODS

2.1 | Animals

The medical databases of 2 referral institutions were searched for dogs with a diagnosis of acute TL IVDE that underwent hemilaminectomy between July 2009 and December 2014. Dogs were included if: (a) complete medical records were available showing presentation with clinical and neurological signs compatible with acute TL IVDE; (b) an IVDE was identified within the T10-L3 IVD spaces; (c) hemilaminectomy was performed without prophylactic fenestration of any IVDs, including the affected site; (d) MRI images were available with a minimum of a T2-weighted (T2W) sagittal view encompassing all IVD spaces between T10 and L3 as well as T2W transverse views of the site of extrusion; and (e) clinical recovery after surgical decompression had been documented and follow-up was available for a minimum period of 6 months. Improvement after surgical decompression was defined as a reduction of at least 1 neurological grade from that recorded before surgery at a 4 to 8 week recheck. Neurological grading was defined as paraplegia without deep pain perception (grade 5), paraplegia with intact deep pain perception (grade 4), nonambulatory paraparesis (grade 3), ambulatory paraparesis and ataxia (grade 2), spinal hyperesthesia only (grade 1).²²

Information retrieved from the medical records included age, gender, neuter status, breed, neurological grade at presentation, and the site of extrusion and associated hemilaminectomy. Information regarding previous episodes of IVDE was not collected. Breeds were categorized as chondrodystrophic or nonchondrodystrophic according to previous publications, chondrodystrophic breeds including the Dachshund, Basset Hound, French Bulldog, Cocker Spaniel, Shi Tzu, Pekingese, and the Pembroke Welsh Corgi.^{1,23}

2.2 | Recurrence and follow-up

All animals were investigated for late recurrence by obtaining a full medical history and through telephone interviews with the referring veterinary surgeons or owners. Late recurrence was investigated in this study, in opposition to early recurrence (occurring before 8 weeks postoperatively) where typically the same IVD is involved.⁶ Late recurrence was mentioned throughout the manuscript as “recurrence” unless stated otherwise. Recurrence was defined as clinical or neurological signs attributable to a suspected or confirmed TL IVDE, at least 8 weeks after surgical management of the initial episode, and after a documented improvement after surgery. Clinical signs designating recurrence included any deterioration in the neurological status including spinal hyperesthesia, pelvic limb ataxia, paraparesis or paraplegia, which were not apparent at the time of clinical recovery

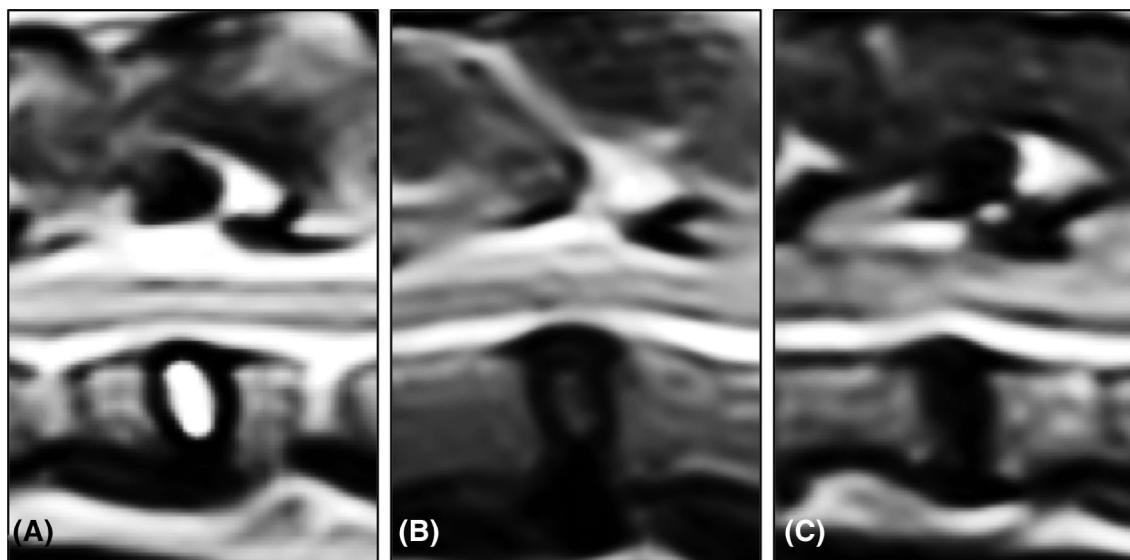


FIGURE 1 Disc degeneration based on nucleus pulposus signal intensity on midsagittal T2W images. A, Nondegenerate, B, partially, and C, completely degenerate intervertebral disc

documented at 4 to 8 weeks after initial surgery, and which were compatible with TL IVDE. Neurological grading at recurrence was recorded, as was the time from initial surgery to recurrence. At the time of data acquisition, clinical histories were analyzed in order to determine which cases had a recurrence confirmed by a direct consultation with a neurologist at the referral hospital, which were then graded according to their presenting neurological dysfunction. All owners were also interviewed by telephone to explore the possibility of additional recurrences. When this was reported, contact was made with the referring veterinarian in order to determine the neurological grading as assessed by them at the time of recurrence. Cases in which clinical recurrence was mentioned by owners but not confirmed by a consultation with either a specialist or the referring veterinarian, were not considered as recurrence cases. Recurrence was confirmed with MRI when possible and information regarding the site of any recurrence was retrieved. The study population was then divided into 2 subsets: recurrence and nonrecurrence groups.

2.3 | Magnetic resonance imaging assessment

Magnetic resonance imaging was performed using a 0.25 Tesla permanent magnet at both institutions (Esaote VetMR Grande, Genova, Italy) under general anesthesia and included T2W sagittal and transverse sequences, with variable time of echo (TE 120 ms), time of repetition (TR 3000-4500 ms) and slice thickness (3-4.5 mm) because acquisition protocols were not standardized between institutions. T2W mid-sagittal MRI of the vertebral column between T10 to L3 of included dogs was retrieved. MRI-studies were blinded and presented in a randomized order to a board-certified neurologist (Paul Freeman), with the observer being informed of the location of the affected (extruded) IVD. Standard image archiving and communication system

software (Osirix v.9.0.1) was used to view and assess the imaging studies. For each included dog, the blinded observer assessed MRI features of disc degeneration, based on nucleus pulposus signal intensity on midsagittal T2W images according to previous reports.^{24,25} All IVDs within the T10-L3 range were examined. The currently extruded IVD was not included in the analysis because they were expected to be at least partially degenerate given our inclusion criteria. A “non-degenerate IVD” was defined as having a homogenous T2W hyperintense signal in the nucleus pulposus, a “partially degenerate IVD” had heterogeneous loss of T2W hyperintense signal, and a “completely degenerate IVD” had complete loss of T2W hyperintense signal (Figure 1). Completely or partially degenerate IVDs, anywhere within the T10-L3 interval as well as specifically in adjacent IVDs to the affected one, were recorded. The total number of degenerate IVDs, completely or partially, within the T10-L3 interval was recorded (the affected disc was not included in this total number). If a follow-up MRI was available at recurrence, the location of the site of extrusion was recorded. The presence of other spinal cord compressive sites other than the IVDE, causative of neurological dysfunction at presentation, was not recorded.

2.4 | Statistical analysis

Cox proportional hazards regression was used to explore the association of recurrence of IVDE with evidence of disc degeneration at other T10-L3 sites, including the total number of degenerate discs found (both completely and partially degenerate), the identification of at least 1 partially degenerate disc and, lastly, the identification of any (at least 1) completely degenerate disc. Other putative factors including chondrodystrophism, neurologic grade at presentation and age were also explored relating to IVDE recurrence. Dogs that did not

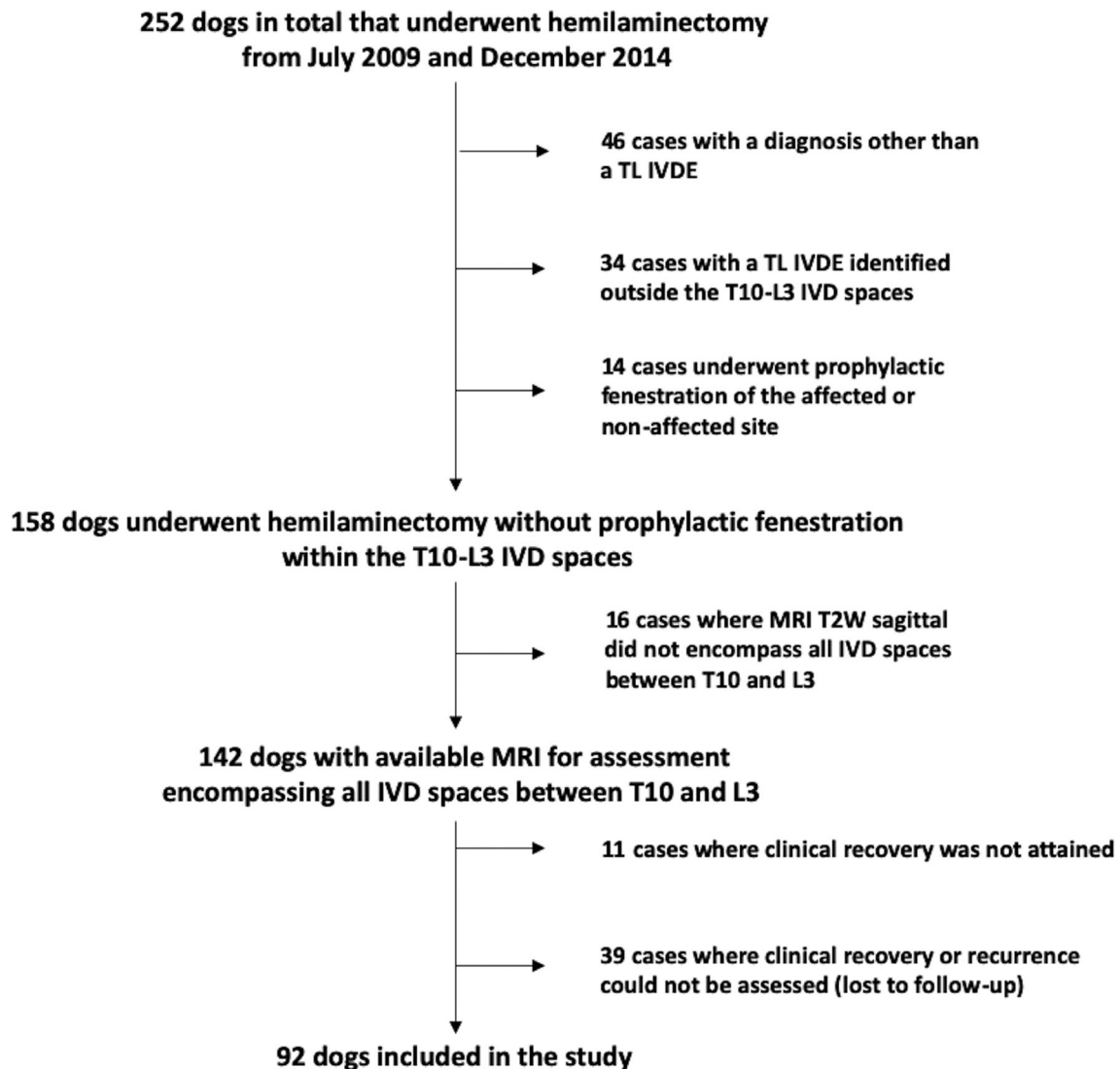


FIGURE 2 Flowchart indicating the finally included sample and reasons for exclusion of other dogs at various stages

show signs of recurrence were censored in analysis at the date when they were last available for follow-up. Factors were initially examined by univariable analysis and then explanatory variables associated with recurrence in the univariable regression model ($P < .20$) were carried forward to the multivariable model. The multivariable model was built using a manual backward stepwise approach to identify the variables associated with recurrence ($P < .05$) while adjusting for possible confounding factors.

3 | RESULTS

3.1 | Included animals

A total of 252 dogs were found that underwent hemilaminectomy at both referral institutions during the selected time period, details for exclusion are included as a flowchart (Figure 2). Ninety-two dogs were included, of which 33 (35.9%) later presented signs compatible with

recurrence of TL IVDE. Recurrence and its neurological grading was assessed directly by a neurology specialist in 22/33 (66.7%) cases or by the referring veterinary surgeon in the remaining cases. The breed distribution, age, sex, and neutered status of recurrence and non-recurrence cases are described in detail in Table 1, as well as the initial neurological status and at recurrence and the follow-up time. Bodyweight was available in all cases, with a median of 7.5 kg (2.35–44.2 kg). At the time of clinical data collection, no additional recurrences were recorded in any dog.

3.2 | Magnetic resonance imaging analysis

Affected IVDs ($n = 97$), in order of prevalence were T12-T13 (30), T13-L1 (23), L1-L2 (17), T11-T12 (16), L2-L3 (9), and T10-T11 (2). Multiple IVDs were extruded and operated in 5 cases, with 2 affected sites in each. In these 5 cases, both spaces were eliminated from analysis of degeneration. A total of 455 IVDs were analyzed, 164 in the

TABLE 1 Signalment, neurological grade, time to recurrence, and follow-up time for the total population and the recurrence and nonrecurrence groups. N, number; NA, not applicable

	Total population	Recurrence group	Nonrecurrence group
Age at presentation (years), median (range)	5.3 (2-14)	5.4 (2-14)	5.25 (3.67-10)
Sex			
Male, n (%)	52 (56.52)	22 (66.7%)	30 (50.08%)
Female, n (%)	40 (43.47)	11 (33.3%)	29 (49.15%)
Neutering status			
Neutered, total n (%)	65 (70.65)	23 (69.69)	42 (71.18)
Neutered female n (%)	30 (32.60)	9 (27.27)	21 (35.59)
Neutered male n (%)	35 (38.04)	14 (42.42)	21 (35.59)
Entire, total n (%)	27 (29.34)	10 (30.30)	17 (28.81)
Entire female n (%)	10 (10.86)	2 (6.06)	8 (13.55)
Entire male, n (%)	17 (18.47)	8 (24.24)	9 (15.25)
Breed distribution			
Chondrodystrophic, n (%)	60 (65.21)	22 (66.66)	38 (64.40)
Dachshund, n (%)	42 (45.64)	16 (48.48)	26 (44.06)
Cocker Spaniel, n (%)	9 (9.78)	5 (15.15)	4 (6.77)
Jack Russell Terrier, n (%)	8 (8.69)	3 (9.09)	5 (8.47)
Pembroke Welsh Corgi, n (%)	4 (4.34)	3 (9.09)	1 (1.69)
Crossbreed, n (%)	5 (5.43)	1 (3.03)	4 (6.77)
Shih-Tzu, n (%)	6 (6.52)	1 (3.03)	5 (8.47)
Labrador, n (%)	3 (3.26)	1 (3.03)	2 (3.38)
Papillon, n (%)	2 (2.17)	1 (3.03)	1 (1.69)
Clumber Spaniel, n (%)	1 (1.08)	1 (3.03)	0 (0)
Staffordshire Bull Terrier, n (%)	2 (2.17)	1 (3.03)	1 (1.69)
Pekingese, n (%)	6 (6.52)	3 (9.09)	3 (5.08)
Dobermann, n (%)	1 (1.08)	1 (3.03)	0 (0)
Basset Hound, n (%)	1 (1.98)	1 (3.03)	0 (0)
Border Terrier, n (%)	1 (1.98)	1 (3.03)	0 (0)
Chihuahua, n (%)	1 (1.98)	1 (3.03)	0 (0)
Toy Poodle, n (%)	1 (1.98)	1 (3.03)	0 (0)
German Shepherd Dog, n (%)	1 (1.98)	1 (3.03)	0 (0)
Rottweiler, n (%)	1 (1.98)	1 (3.03)	0 (0)
Initial neurological grade			
Grade 1, n (%)	5 (54.35)	2 (6.06)	3 (5.08)
Grade 2, n (%)	19 (20.65)	4 (12.12)	15 (45.45)
Grade 3, n (%)	24 (26.09)	7 (21.21)	17 (51.52)
Grade 4, n (%)	44 (47.83)	20 (60.6)	24 (40.68)
Grade 5, n (%)	0	0	0
Neurological grade at recurrence			
Grade 1, n (%)	NA	24 (72.72)	NA
Grade 2, n (%)	NA	5 (15.15)	NA
Grade 3, n (%)	NA	3 (9.09)	NA
Grade 4, n (%)	NA	1 (3.03)	NA
Grade 5, n (%)	NA	0	NA
Time to recurrence (months), median (range)	NA	16 (3-72)	NA
Follow-up time (months), median (range)	44.5 (6-104)	46 (9-104)	43 (6-95)

recurrence group and 291 in the nonrecurrence group. A total of 175 nonaffected IVDs were analyzed, 62 in recurrence group and 113 in the nonrecurrence group. The presence and distribution of completely degenerate and partially degenerate IVDs among the 2 groups studied (recurrence and nonrecurrence) are described in Table 2.

Univariable Cox regression analysis suggested recurrence was associated, even at $P < .2$, only with “presence of any completely degenerate disc” (hazard ratio [HR] = 2.92; 95% confidence interval [CI]: 1.37-6.20; $P = .005$; Table 3). A multivariable model in which the other, possibly confounding, variables (chondrodystrophism, age, neurologic score at presentation and presence of partially degenerated

discs) did not substantially alter the hazard ratio associated with diagnosis of a completely degenerate disc (HR = 2.91; 95% CI: 1.28-6.58) and was not superior to the univariable model (likelihood ratio test $\chi^2 = 1.43$; $P = .92$). The association indicated a point estimate increased hazard of recurrence of ~290% vs dogs that do not have another completely degenerate disc. The Nelson-Aalen cumulative hazard plot (Figure 3) illustrates the difference in cumulative hazard of recurrence after initial surgery between dogs with and without a completely degenerate disc elsewhere in the T10-L3 region over the whole follow-up time available (up to ~8 years in some individuals, see Table 1).

TABLE 2 Details on the total number and percentage of magnetic resonance assessed degenerated discs in the T10-L3 interval, among the recurrence and nonrecurrence groups, at the time of initial intervertebral disc extrusion

	Recurrence group	Nonrecurrence group
Number of completely degenerate discs in the T10-L3 interval/total number of assessed discs (percentage)	31/164 (18.9%)	41/291 (14.1%)
Number of partially degenerate discs in the T10-L3 interval/total number of assessed discs (percentage)	103/164 (62.8%)	191/291 (65.6%)
Number of completely degenerate discs adjacent to the affected disc/total number of adjacent assessed discs (percentage)	17/62 (27%)	12/113 (10.6%)
Number of cases with at least 1 completely degenerate disc in the T10-L3 interval/total number of cases (percentage)	22/33 (67%)	22/59 (37%)

TABLE 3 Factors assessed for association with intervertebral disc extrusion recurrence in univariable analyses

Factor	HR	95% CI	P-value
MRI assessed disc degeneration			
Number of degenerate intervertebral discs (both completely and partially)	1.09	0.83-1.42	.54
Presence of at least 1 completely degenerate intervertebral disc	2.92	1.38-6.20	.005
Presence of at least 1 partially degenerate intervertebral disc	1.14	0.27-4.80	.86
Other putative factors			
Chondrodystrophic	1.24	0.59-2.59	.57
Age	0.98	0.83-1.16	.83

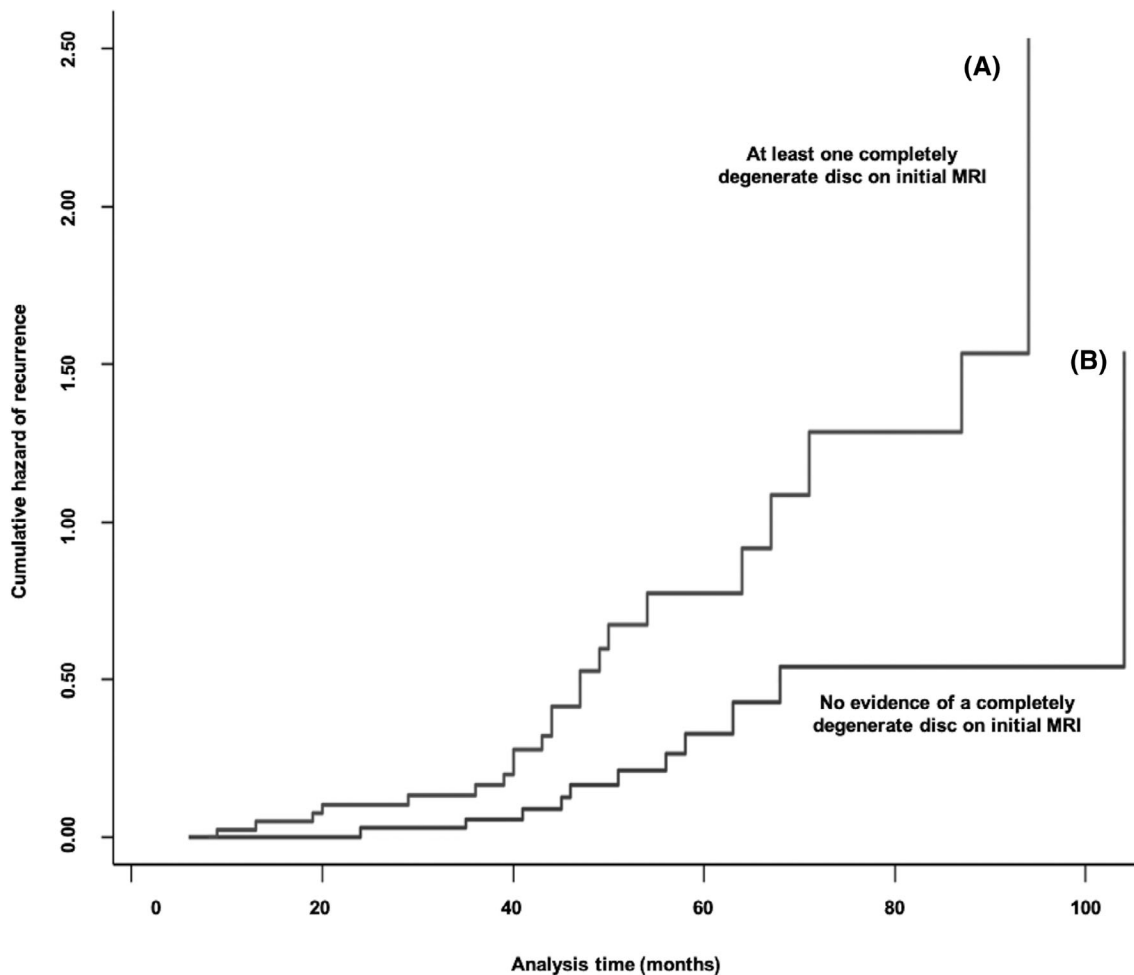
Abbreviations: CI, confidence interval; HR, hazard ratio; MRI, magnetic resonance imaging.

3.3 | Follow-up MRI findings

Recurrence was confirmed by a second MRI in 8/33 cases, all of which underwent a second decompressive surgery and subsequently improved clinically. Details of this subpopulation are described in Table 4. In 1 case, there was recurrence at the previously affected site (T13-L1). When a newly affected IVD was found, 3 cases presented a new herniation in 1 of the adjacent IVDs, 2 cases herniated within 1 IVD space away whereas the remaining 2 cases herniated more than 1 IVD space away from the initial site. The new herniating site was outside the T10-L3 region in 2 cases, both at L5-L6 which were reassessed. Initial IVD status in these cases was “completely degenerate” (5) and “partially degenerate” (3). In 25 cases, recurrence was not confirmed with diagnostic imaging. Four cases were euthanized at this stage but the remaining 21 dogs were all managed successfully by conservative methods.

4 | DISCUSSION

This study demonstrated a correlation between MRI assessed disc degeneration and presumed postoperative IVDE late recurrence, which had only been demonstrated for radiographically visible disc calcification.^{7,10} However, it is important to highlight that this is a retrospective, exploratory study, in which degeneration of other discs in the TL region was explored for association with recurrence of signs



	0 months	20 months	40 months	60 months	80 months	100 months	120 months
Total number of dogs at risk	92	73	54	20	7	1	1
Number of animals analyzed at specific time points	Total number recurrences A	0	4	9	17	20	22
	Total number recurrences B	0	0	2	8	10	11
	Total number recurrences A+B	0	4	11	25	30	33

FIGURE 3 Cumulative hazard of recurrence with time after initial surgery between dogs with and without a completely degenerate disc elsewhere in the T10-L3 region (Nelson-Aalen cumulative hazard plot); x-axis is time after surgery in months, y-axis is the cumulative hazard or recurrence of clinical signs. The difference between the lines for dogs with and without a completely degenerate disc elsewhere in the T3-L3 region corresponds to the hazard ratio of 2.92 (95% CI: 1.37-6.20) obtained by Cox proportional hazards regression. A, Indicates evidence of at least 1 completely degenerate disc on initial MRI; B, Indicates no evidence of a completely degenerate disc on initial magnetic resonance imaging (MRI). This demonstrates a cumulative hazard of recurrence for dogs with at least 1 completely degenerate disc, corresponding to a hazard ratio of 2.92 obtained with Cox analysis

consistent with TL IVDE and so the findings require independent replication. Other putative factors explored including chondrodystrophy and age did not appear to be associated with a similar risk for recurrence as the presence of any completely degenerate IVD on initial MRI.

A single previous study has explored the relationship between several radiographic features and recurrence of IVD herniation, with

only evidence of IVD mineralization at the time of first surgery being reported as a risk factor.⁷ In that report, each additional calcified IVD between the T10-L4 spaces was associated with an increased risk of recurrence of 1.4 times baseline, although no statistically significant difference was found in the total numbers of calcified IVDs between recurrence and nonrecurrence groups.⁷ Despite radiographically identified IVD calcification being a manifestation of disc degeneration, it is

TABLE 4 Magnetic resonance imaging (MRI) confirmed recurrence cases details, regarding the site of initial and recurrence intervertebral disc extrusions (IVDEs), with details on recurrence sites initial grading on MRI

Site of initial IVDE	Recurrence site	Initial disc degeneration grade of recurrence site	Time from initial surgery to recurrence (months)
T11-L2	Adjacent (T12-T13)	Completely	45
T12-L3	Adjacent (T13-L1)	Completely	27
T12-L3	Adjacent (T11-T12)	Completely	17
T13-L1	Nonadjacent (L2-L3)	Partially	12
T13-L1	Nonadjacent (L2-L3)	Partially	6
T13-L1	Nonadjacent (L5-L6)	Completely	14
T13-L1	Same (T13-L1)	Completely	6
T13-L1	Nonadjacent (L7-S1)	Partially	27

known that severe degeneration identified postmortem may also occur in the absence of radiologically visible calcification.^{1,15} Radiographic evaluation underestimates the true prevalence of disc degeneration, with MRI being considered the most reliable diagnostic tool to evaluate IVD degeneration in dogs.²⁶ Our study was the first attempt to relate MRI features with late recurrence in dogs, revealing that the presence of at least 1 completely degenerate disc at time of initial surgery is associated with recurrence, which is in agreement with previous reports.^{7,10}

Intervertebral disc degeneration on MRI is associated with a decrease in nucleus pulposus signal intensity on T2W images.²⁶ The nucleus pulposus in a nondegenerate disc is expected to present a uniform T2W hyperintense signal because its gelatinous contents are still water-rich (2, 26). The 3-category system utilized in this study has been employed in several other studies^{24,25,27,28} and, although there are other options, we felt this simple system had the potential of providing a more straightforward assessment tool than the 5 category Pfirrmann system, which, nevertheless, does correlate with histological findings in dogs.^{26,29}

We chose a sample of dogs in which no fenestration was performed at the time of surgery to obtain information regarding suspected recurrence in the absence of prophylactic fenestration, because this technique reduces the incidence of recurrence^{9,12} and 1 initial aim of this study was to provide better guidelines for when fenestration could have the most prophylactic impact. Despite the lack of data directly supportive of prophylactic fenestration in this study, the increased risk of recurrence when there are other completely degenerate IVDs suggested a possible specific indication for prophylactic fenestration at the time of decompressive surgery that could be investigated in future studies.

The majority of recurrences were of mild clinical signs only, with 24/33 (73%) presenting with spinal hyperesthesia alone, thus explaining the small proportion of cases (8/33) that underwent a second MRI and a second surgery. It is also possible that further imaging and potential surgical treatment was declined for financial reasons—indeed, 4/33 dogs in our study were euthanized because of recurrence of signs. This is an important consideration and 1 of the reasons for this study: to derive evidence-based recommendations that will reduce the proportion of dogs that show recurrence but are not

investigated or treated through emotional or financial depletion of the caregiver. Time to recurrence in this study varied greatly, between 3 and 72 months with a median of 16 months. It is reasonable to consider that the initially assessed grade of complete degeneration may have a greater predictive value for recurrence occurring earlier rather than later, but the limited number of cases at distinct time points of recurrence in our population prevented this analysis.

When reviewing cases for which imaging confirmation of recurrence was available, some degeneration of the IVD that caused the recurrence was evident at the time of initial presentation. Recurrence at a nonadjacent site occurred in 4/8 of cases, at an adjacent site in 3/8, and at the initially affected disc in 1/8 cases. This study did not therefore provide strong evidence to support previous findings that the majority of late recurrence of TL IVDE occur at a site adjacent to that initially affected or adjacent to a fenestrated disc.^{2,6,7,9,10} Because no IVDs were fenestrated in our sample, it may be that adjacent discs were not affected biomechanically in the same way as when the extruded disc has been fenestrated,^{30,31} although this could be a spurious finding. Because of the small number of cases which did not have repeat imaging at the time of recurrence.

This study was limited by its retrospective nature, possibly further complicated by gathering cases from 2 different institutions. Recurrence included cases in which there was spinal hyperesthesia alone, and recurrence was, in some instances, assessed by the referring veterinarians (11/33; 33%) or not confirmed by advanced imaging (25/33; 76%). We consider our approach of using clinical evidence of suspected recurrence was reasonable, because this approach has been used in previous studies,^{10,29} and exclusion of cases without imaging confirmation is likely to underestimate the true rate of recurrence. Furthermore, in clinical practice, it is important to know the rate of recurrence of clinical signs compatible with TL IVDE regardless of whether these are confirmed with imaging or surgical findings, because this will concern owners of affected dogs. No grade 5 dogs were evaluated in this study, therefore, no conclusions could be drawn in terms of generalizability of our results to this specific subpopulation of more severely affected dogs. Follow-up time after initial TL IVDE was not uniform in this study, because of its retrospective nature, and it is reasonable to assume that some nonrecurrence dogs with a shorter follow-up time could have indeed suffered from

recurrences at a later point. Imaging in this study was performed on low-field MRI, which could limit the generalizability to diagnosis made on other equipment, although the identification of “complete degeneration” is likely to be equivalent.²⁶

In conclusion, this study demonstrated that identification of at least 1 additional completely degenerate disc in the TL region of dogs diagnosed with a TL IVDE significantly increased the risk of recurrence of clinical signs associated with another IVDE and suggested the need for greater consideration of prophylactic fenestration.

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CONFLICT OF INTEREST DECLARATION

Authors declare no conflict of interest.

OFF-LABEL ANTIMICROBIAL DECLARATION

Authors declare no off-label use of antimicrobials.

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE (IACUC) OR OTHER APPROVAL DECLARATION

Informed consent was obtained from all owners.

HUMAN ETHICS APPROVAL DECLARATION

Authors declare human ethics approval was not needed for this study.

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REFERENCES

- Hansen HJ. A pathologic-anatomical study on disc degeneration in dog, with special reference to the so-called enchondrosis intervertebralis. *Acta Orthop Scand*. 1952;11:1-117.
- Brisson BA. Intervertebral disc disease in dogs. *Vet Clin North Am Small Anim Pract*. 2010;40(5):829-858. <https://doi.org/10.1016/j.cvsm.2010.06.001>.
- Langerhuus L, Miles J. Proportion recovery and times to ambulation for non-ambulatory dogs with thoracolumbar disc extrusions treated with hemilaminectomy or conservative treatment: a systematic review and meta-analysis of case-series studies. *Vet J*. 2017;220:7-16.
- Black A. Lateral spinal decompression in the dog: a review of 39 cases. *J Small Anim Pract*. 1988;29(9):581-588.
- Funkquist B. Decompressive laminectomy in thoracolumbar disc protrusion with paraplegia in the dog. *J Small Anim Pract*. 1970;11:445-451.
- Dhupa S, Glickman N, Waters DJ. Reoperative neurosurgery in dogs with thoracolumbar disc disease. *Vet Surg*. 1999;28:421-428.
- Mayhew PD, McLear RC, Ziemer LS, et al. Risk factors for recurrence of clinical signs associated with thoracolumbar intervertebral disk herniation in dogs: 229 cases (1994–2000). *J Am Vet Med Assoc*. 2004;225:1231-1236.
- Brisson BA, Moffatt SL, Swayne SL, Parent JM. Recurrence of thoracolumbar intervertebral disk extrusion in chondrodystrophic dogs after surgical decompression with or without prophylactic fenestration: 265 cases (1995–1999). *J Am Vet Med Assoc*. 2004;224:1808-1814.
- Aikawa T, Fujita H, Shibata M, Takahashi T. Recurrent thoracolumbar intervertebral disc extrusion after hemilaminectomy and concomitant prophylactic fenestration in 662 chondrodystrophic dogs. *Vet Surg*. 2012;41(3):381-390.
- Brisson BA, Holmberg DL, Parent J, Sears WC, Wick SE. Comparison of the effect of single-site and multiple-site disk fenestration on the rate of recurrence of thoracolumbar intervertebral disk herniation in dogs. *J Am Vet Med Assoc*. 2011;238:1593-1600.
- Ruddle TL, Allen DA, Schertel ER, et al. Outcome and prognostic factors in non-ambulatory Hansen type I intervertebral disc extrusions: 308 cases. *Vet Comp Orthop Traumatol*. 2006;19(01):29-34.
- Freeman P, Jeffery ND. Re-opening the window on fenestration as a treatment for acute thoracolumbar intervertebral disk herniation in dogs. *J Small Anim Pract*. 2017;58(4):199-204. <https://doi.org/10.1111/jsap.12653>.
- Jeffery ND, Freeman PM. The role of fenestration in management of type I thoracolumbar disk degeneration. *Vet Clin North Am Small Anim Pract*. 2018;48(1):187-200. <https://doi.org/10.1016/j.cvsm.2017.08.012>.
- Knapp DW, Pope ER, Hewett JE, Bojrab MJ. A retrospective study of thoracolumbar disk fenestration in dogs using a ventral approach: 160 cases (1976-1986). *J Am Anim Hosp Assoc*. 1990;26(5):543-549.
- Jensen VF, Beck S, Christensen KA, Arnbjerg J. Quantification of the association between intervertebral disk calcification and disk herniation in Dachshunds. *J Am Vet Med Assoc*. 2008;233:1090-1095.
- Besalti O, Pekcan Z, Sirin S, Erbas G. Magnetic resonance imaging findings in dogs with thoracolumbar intervertebral disk disease: 69 cases (1997-2005). *J Am Vet Med Assoc*. 2006;228(6):902-908. <https://doi.org/10.2460/javma.228.6.902>.
- Naude SH, Lambrechts NE, Wagner WM, Thompson PN. Association of preoperative magnetic resonance imaging findings with surgical features in Dachshunds with thoracolumbar intervertebral disk extrusion. *J Am Vet Med Assoc*. 2008;232:702-708.
- Gopal MS, Jeffery ND. Magnetic resonance imaging in the diagnosis and treatment of a canine spinal cord injury. *J Small Anim Pract*. 2001;42:29-31.
- Robertson I, Thrall DE. Imaging dogs with suspected disc herniation: pros and cons of myelography, computed tomography, and magnetic resonance. *Vet Radiol Ultrasound*. 2011;52:81-84. <https://doi.org/10.1111/j.1740-8261.2010.01788.x>.
- Bos AS, Brisson BA, Nykamp SG, Poma R, Foster RA. Accuracy, inter-method agreement, and inter-reviewer agreement for use of magnetic resonance imaging and myelography in small-breed dogs with naturally occurring first-time intervertebral disk extrusion. *J Am Vet Med Assoc*. 2012;240:969-977.
- Sether LA, Nguyen C, Yu S, et al. Canine intervertebral disks: correlation of anatomy and MR imaging. *Radiology*. 1990;175:207-211.
- Scott HW. Hemilaminectomy for the treatment of thoracolumbar disc disease in the dog: a follow-up study of 40 cases. *J Small Anim Pract*. 1997;38:488-494.
- Smolders LA, Bergknut N, Grinwis GCM, et al. Intervertebral disc degeneration in the dog. Part 2: Chondrodystrophic and non-chondrodystrophic breeds. *Vet J*. 2013;195(3):292-299.
- da Costa RC, Parent JM, Partlow G, Dobson H, Holmberg DL, LaMarre J. Morphologic and morphometric magnetic resonance imaging features of Doberman Pinschers with and without clinical signs of cervical spondylomyelopathy. *Am J Vet Res*. 2006;67:1601-1612.
- Gomes SA, Volk HA, Packer RM, et al. Clinical and magnetic resonance imaging characteristics of thoracolumbar intervertebral disk extrusions and protrusions in large breed dogs. *Vet Radiol Ultrasound*. 2016;57(4):417-426. <https://doi.org/10.1111/vru.12359>.
- Bergknut N, Auriemma E, Wijsman S, et al. Evaluation of intervertebral disk degeneration in chondrodystrophic and nonchondrodystrophic dogs

- by use of Pfirrmann grading of images obtained with low-field magnetic resonance imaging. *Am J Vet Res.* 2011;72(7):893-898.
27. De Decker S, Gielen IM, Duchateau L, et al. Intraobserver and interobserver agreement for results of low-field magnetic resonance imaging in dogs with and without clinical signs of disk-associated wobbler syndrome. *J Am Vet Med Assoc.* 2011;238(1):74-80.
 28. De Decker S, Gomes SA, Packer RM, et al. Evaluation of magnetic resonance imaging guidelines for differentiation between thoracolumbar intervertebral disk extrusions and intervertebral disk protrusions in dogs. *Vet Radiol Ultrasound.* 2016;57:526-533.
 29. Kranenburg HJ, Grinwis GC, Bergknut N, et al. Intervertebral disc disease in dogs—part 2: comparison of clinical, magnetic resonance imaging, and histological findings in 74 surgically treated dogs. *Vet J.* 2013;195:164-171.
 30. Hill TP, Lubbe AM, Guthrie AJ. Lumbar spine stability following hemilaminectomy, pediclectomy, and fenestration. *Vet Comp Orthop Traumatol.* 2000;13(04):165-171.
 31. De Vicente F, Bernard F, Fitzpatrick D, Moissonnier P. In vitro radiographic characteristics and biomechanical properties of the canine lumbar vertebral motion unit after lateral corpectomy, mini-hemilaminectomy and hemilaminectomy. *Vet Comp Orthop Traumatol.* 2013;26(01):19-26.

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