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CLINICAL RESEARCH

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Recurrence of cervical intervertebral disc extrusion in 55 dogs after surgical decompression with or without prophylactic fenestration

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Abstract

Objective: To determine whether prophylactic fenestration (PF) of adjacent intervertebral discs decreases the recurrence rate (RR) of cervical intervertebral disc extrusion (C-IVDE) in small dogs undergoing ventral slot (VS) decompression, and whether PF increases perioperative complication risk.

Study design: Retrospective, multi-institutional cohort study.

Sample population: A total of 55 dogs.

Methods: Medical records of a mixed population of small dogs (<20 kg) treated with VS for C-IVDE with a minimum one-year follow-up were reviewed. During surgery, dogs underwent either single-site PF, multiple-site PF, or no PF. Perioperative complication rate and RR were compared between PF and non-PF groups using generalized linear models. Surgical time and neurologic grade (presurgery, post-surgery, at first recheck) were compared with Mann–Whitney test and chi-squared tests.

Results: A total of 55 dogs were included (PF: $n = 18$; non-PF: $n = 37$). Neurologic grades were similar at all timepoints. Median time to first recheck was 14 days (range: 5–56). Median follow-up time was 1380 days (range: 365–2777). Recurrence occurred in 25% of dogs (14/55), all in the non-PF group. Prophylactic fenestration was associated with a lower RR ($p < .001$). Surgery duration was longer in the PF group (158.0 ± 13.5 min) versus non-PF (118.0 ± 6.8 min, $p = .017$), but complication rates were similar (18.2%, $p = .838$) between groups.

Abbreviations: ASA, American Society of Anesthesiologists; BCS, Body condition score; C-IVDE, Cervical intervertebral disc extrusion; CT, Computed tomography; IVDD, Intervertebral disc disease; MRI, Magnetic resonance imaging; PF, Prophylactic fenestration; RR, Recurrence rate; T-IVDE, Thoracolumbar intervertebral disc extrusion; VS, Ventral slot.

This study was presented as an oral presentation at the European College of Veterinary Neurology (ECVN) Symposium on September 23, 2023, in Venice, Italy.

Conclusion: Recurrence of C-IVDE is more likely to occur at non-PF group than PF-group in a heterogenous population of small breed dogs. Prophylactic fenestration was not linked to increased complication risk.

Clinical significance: Prophylactic fenestration might be safely considered to prevent C-IVDE recurrence.

1 | INTRODUCTION

Extrusion or Hansen type I intervertebral disc disease (IVDD) is the most common cause of myelopathy in dogs and affects mostly small chondrodystrophic dog breeds. Cervical intervertebral disc extrusion (C-IVDE) accounts for 12.9% to 25.4% of all IVDD in dogs.[1,2] When significant neurologic deficits are present or when there is a poor response to conservative treatment, surgical decompression of the spinal cord with a ventral slot (VS) is the treatment of choice in most cases.[2,3]

Recurrences are a major concern following IVDD surgery. A recurrence rate (RR) ranging from 3% up to 42% has been reported in dogs treated surgically for thoracolumbar intervertebral disc extrusion (T-IVDE).[4–14] For C-IVDE, RR ranging from 2% up to 64% have been observed.[13,15–18] Despite a good to excellent prognosis when deep pain sensation is still present, owners sometimes unfortunately opt for humane euthanasia due to the financial burdens of a second or third surgery, or because of the distress caused by their animal's pain and/or severe neurologic deficits.

Prophylactic fenestration (PF) involves creating a small window in the annulus fibrosus to remove part of the nucleus pulposus from adjacent or distant degenerated intervertebral discs during IVDD surgery.[19] Prophylactic fenestration may also be considered for non-degenerated disc spaces. Various techniques can be used, including manual fenestration using a scalpel blade, power-assisted using a burr, percutaneously by laser disc ablation (PLDA), by cavitron ultrasonic surgical aspiration (CUSA), vacuum aspiration, chemonucleolysis or discolysis by injection of radiopaque gelified ethanol.[20–24] The relevance of PF is still the subject of debate among veterinary surgeons and neurosurgeons. It has been primarily advocated to reduce the recurrence of IVDD at another disc space in predisposed dogs, especially since fenestration of the affected disc seems to prevent further recurrence at that site.[4–11,15] A study comparing fenestrated and non-fenestrated discs in a population of dogs that underwent PF during their first T-IVDE episode showed that non-fenestrated thoracolumbar discs are 26.2 times more likely to be responsible for a T-IVDE recurrence than fenestrated discs.[11] Additionally, up to 70% of IVDE recurrences occur at intervertebral disc spaces adjacent to the surgically treated site, discs that could have been prophylactically fenestrated during the initial surgery, without the need for a separate surgical approach.[4,7,8,10,11] These findings raised the question of whether PF should be systematically considered in every case.

Although PF of intervertebral discs, when degenerated or mineralized, appears to be effective in reducing the recurrence of T-IVDE in dogs, the authors of a recent systematic review concluded that, despite a large number of relevant publications on this topic, the quality of the evidence they provide is low and a definitive conclusion cannot be drawn from the current veterinary literature.[25] One argument against PF is that intervertebral discs play an important role in stabilizing the vertebral column, especially in the cervical region.[26] This procedure, particularly when multiple sites are fenestrated, can cause vertebral column instability, which might lead to vertebral collapse and subluxation.[27] Prophylactic fenestration is also thought to significantly lengthen the duration of surgery and increase the amount of soft tissue dissection, thereby increasing the risk of perioperative complications due to the extension of the surgical approach. This can increase soft tissue trauma and the risk of surgical site infection.[26,28] Nevertheless, PF is recommended by the latest 2022 ACVIM consensus on T-IVDE for adjacent degenerated discs and for some breeds at risk of recurrence.[29] To date, studies have focused primarily on the effect of PF in dogs treated for T-IVDE, but so far, no study has compared the recurrence rate between fenestrated and non-fenestrated cervical discs in the cervical region.

The objectives of this study were to determine whether concomitant PF of adjacent interverbal disc spaces decreases the RR of C-IVDE in small breed dogs treated by ventral slot (VS) decompression compared with VS alone, and to evaluate whether PF is associated with an increased risk of perioperative surgical complications.

2 | MATERIALS AND METHODS

2.1 | Case selection

Medical records of dogs presented at two different veterinary referral hospitals for C-IVDE that underwent at least one VS decompression procedure between January 1, 2015, and December 31, 2021, were retrospectively reviewed. To be included, dogs had to weigh less than 20 kg and have a complete medical record, which included initial physical examination, pre- and postoperative neurologic status, advanced imaging results and surgery report—including VS and PF site(s) when performed, PF-related complications, as well as clinical outcome. A minimum of 1 year follow-up, based on information retrieved from the medical record and/or a telephone interview with the owner, was also required for inclusion. Dogs that had a previous VS performed in another hospital were excluded.

2.2 | Data collection

The following information was extracted from medical records when available. Complete data could not always be obtained for each dog as the diagnostic tests and treatments provided were performed at the discretion of the veterinarian in charge of the case.

2.2.1 | Demographics, clinical signs and neurologic grades

Data collected from each medical recorded included demographics (age, sex, breed, weight, body condition score [BCS] out of 5 or out of 9), weight status at first episode (overweight if BCS >6/9 or >4/5, normal if BCS between 4/9 and 6/9 or 2/5 and 3/5, underweight if BCS <4/9 or <2/5).[30] The duration of clinical signs at the first episode of C-IVDE was noted and classified into three groups: acute if the patient's clinical signs appeared 7 days before presentation, subacute if they occurred between 7 days and 3 weeks before presentation, and chronic if they persisted for more than 3 weeks before presentation. Neurologic grade was determined based on the initial neurologic examination. Dogs were classified into five categories based on previous studies[5,8,11,31]: (1) cervical pain only, (2) ambulatory tetraparesis, (3) non-ambulatory tetraparesis (4) tetraplegia with deep pain sensation and (5) tetraplegia without deep pain sensation.

2.2.2 | Diagnostic imaging

The primary advanced imaging methods used to diagnose C-IVDE were either computed tomography (CT) or magnetic resonance imaging (MRI). The location, number of disc extrusion(s) and other degenerated discs (hyperattenuating nucleus pulposus on CT or hypointensity on MRI T2-weighted sequences) were noted. All diagnostic procedures and surgeries were performed under the supervision of a board-certified veterinary anesthesiologist.

2.2.3 | Surgery and prophylactic fenestration(s)

For surgery, data collected included surgical duration, location and number of VS decompressions, location, and number of PF sites, if any, as well as perioperative surgical complications. The surgery was performed immediately after diagnostic imaging or the following day. Prophylactic antimicrobial therapy was only administered during the perioperative period for all dogs. Ventral slots were performed using the median approach, without incision of the anulus fibrosus before drilling the disc and vertebrae. Prophylactic fenestrations were performed at the discretion of the surgeon in charge of each case. The criteria for performing PF based on advanced imaging included visible disc mineralization on CT or signs of disc degeneration on MRI. Multiple PF were performed in some dogs when several discs were degenerated or calcified. Fenestration of distant sites was left to the discretion of the surgeon. All surgeons elected to perform PF on adjacent sites when degeneration was identified on MRI or calcification on CT, but not all surgeons chose to perform PF on distant sites when the adjacent discs appeared intact. The stability of the dog under anesthesia as well as the ease of access of the distant discs were two additional factors that participated in the surgeon's decision to fenestrate or not. In one of the hospitals, PF was implemented only after 2018, when two veterinary specialists experienced in the procedure joined the team.

Prophylactic fenestrations were performed through a ventral midline approach using either a #11 blade or a burr. The longus colli muscles were retracted away from the disc using curved Mosquito hemostatic forceps, which were spread open and held in place. When PF was performed with a blade, a square cut was made in the annulus fibrosus and excised. When a burr was used, the annulus fibrosus was drilled. In both procedures, a combination of curette and Kerrison rongeur was then used to remove as much of the nucleus pulposus as possible. No suturing of the muscles was performed after PF, and no tissue graft was applied to the sites. As with PF, postoperative imaging was not standardized and was left to the discretion of the attending clinician.

2.2.4 | Complications

All perioperative complications were documented. Major complications included tracheal or esophageal lesions, nerve damage (such as to the vagosympathetic trunk or recurrent laryngeal nerves), severe hemorrhage requiring blood transfusion and/or interruption of surgery, cardiopulmonary arrest, and death or euthanasia, along with the reason for it, if documented.

2.2.5 | Patient outcome

The postoperative neurologic status, both after surgery and when available at any follow-up, was also documented using the same grading system as the preoperative neurologic status. Outcome was scored using data from the medical record and/or a telephone interview with the owner (see Supplementary Material S1 for additional data). A good outcome was defined as pain relief and a return to functional recovery, including ambulatory status for non-ambulatory dogs. Residual ataxia was considered acceptable if the owner judged that the dog's quality of life was good after surgery. No specific questions were asked about urinary or fecal incontinence, given the low risk of developing such complications after C-IVDE treated with VS. Dogs that remained non-ambulatory, became non-ambulatory after surgery, or continued to exhibit clinical signs of pain after the recovery period were classified as having a poor outcome. In cases of residual ataxia, dogs were also considered to have a poor outcome if the owner perceived their quality of life as unsatisfactory. On the telephone follow-up after the first episode, owners were asked if the dog had signs of cervical pain and/or if the dog had neurologic deficits. If residual deficits were present, there were asked if the quality of life was satisfactory. Additionally, a long-term telephone follow-up was performed to detect other potential recurrences of C-IVDE. Owners were asked if their dog had signs of recurrent cervical pain and/or deterioration of locomotion that were confirmed by a veterinarian (see Supplementary Material S2 for additional data).

2.2.6 | C-IVDE recurrence(s)

For dogs with clinical signs suggesting C-IVDE recurrence, data collected for subsequent episodes, if any, included the date of presentation, success of conservative management, if attempted, and other information, which was the same as for the first surgical episode of C-IVDE. Recurrence was classified into two distinct types: suspected recurrence, indicated by clinical signs consistent with C-IVDE as documented by a neurologic examination performed by a veterinarian; and confirmed recurrence, identified by advanced diagnostic imaging such as CT and/or MRI. When C-IVDE recurrence was confirmed, the site of recurrence was compared to the original extrusion site, and, if applicable, any PF locations were noted to determine whether the recurrence occurred at the previous extrusion site or within a PF site. The outcome of the recurrence was scored in the same way as for the initial C-IVDE episode, using the same set of questions during the long-term telephone follow-up (see Supplementary Material S2 for additional data).

2.3 | Statistical analysis

Statistical analyses were performed using R software version 4.3.1 (R Core Team, 2023)[32] and Excel. The response variables: RR and complication rates, were binary. Consequently, to test if the presence of PF had statistical effects on these variables, standard logistic regression was constructed within generalized linear models (GLMs).[33] In these GLMs, the link logit was used. To obtain the results of the GLMs, likelihood ratio tests were carried out (from the Car package version 3.1.2). For duration of surgery the normality of each group, PF and non-PF dogs, was tested through Shapiro-Wilks tests. For one of these groups data were not normally distributed ($p < .05$) and consequently a Mann–Whitney test was used. Repartition of dogs' neurologic grades of the two groups before, after VS and at recheck were compared using chi-squared tests. A p-value lower than .05 was considered statistically significant.

3 | RESULTS

3.1 | Demographics, clinical signs and neurologic grades

A total of 55 dogs met the inclusion criteria. All surgical procedures were performed by either a board-certified veterinary surgeon or a board-certified neurologist, or by their resident under direct supervision.

The median age at the first episode was 7 years (range: 1–11 years). A total of 27 (27/55, 49.0%) dogs were males (22 (40.0%) neutered and five (9.0%) intact), and 28/55 (50.9%) dogs were females (27 (49.0%) spayed and one (2.0%) intact). There were 53 purebreds and two mixed-breed dogs. Repartition of dogs according to their breed is summarized in Table 1, with Dachshunds being the most represented breed, followed by French Bulldogs and Pugs. Onset and duration of clinical signs were available for 53 (96.4%) of the dogs. A total of 13 (24.5%) had an acute presentation, 19 (35.9%) had a subacute presentation, and 21 (39.6%) had a chronic presentation. Median bodyweight was 8.5 kg (range: 2.5–15.4 kg). Body condition score was available for 47 (85.5%) dogs. Of these, 21 (44.7%) were overweight and 26 (55.3%) had a normal BCS. In terms of preoperative neurologic status at admission, 16/55 (29.1%) of dogs were grade 1, 36/55 (65.4%) were grade 2 and 9/55 (16.3%) were grade 3.

TABLE 1 Repartition of the dogs according to their breed ($n = 55$).

Breed	PF	Non-PF	Total
Dachshund	6	13	19
French Bulldog	4	5	9
Pug	2	4	6
Shih Tzu	0	3	3
Beagle	0	2	2
Poodle	1	1	2
Mixed	0	2	2
Yorkshire Terrier	2	0	2
Chihuahua	0	2	2
Chinese Crested	1	0	1
West-Highland White terrier	0	1	1
Cocker Spaniel	0	1	1
Coton de Tulear	0	1	1
Miniature Pinscher	0	1	1
Pekinese	0	1	1
American Cocker	1	0	1
Maltese	0	1	1

Abbreviations: Non-PF, no prophylactic-fenestration group; PF, prophylactic-fenestration group.

3.2 | Diagnostic imaging

Compression caused by C-IVDE was diagnosed using MRI for 39 (70.9%) dogs and CT for 16 (29.1%) dogs. No dog required both MRI and CT for the diagnosis of C-IVDE. Sixty extruded discs were surgically removed by VS. Fifty (90.9%) dogs had one site of C-IVDE and five (9.1%) dogs had two sites. Affected discs were C2–3 for 17/55 (30.9%) dogs, C3–4 for 17/55 (30.9%) dogs, C4–5 for 10/55 (18.1%) dogs, C5–6 for 13/55 (23.6%) dogs and C6–7 for 3/55 (5.4%) dogs (Figure 1).

3.3 | Surgery and prophylactic fenestration(s)

Median surgery time for all dogs was 160 min (range: 65–228 min). Surgery time was longer for PF-dogs (median: 182 min, range: 65–360 min) compared to the non-PF group (median: 110 min, range: 65–231 min) ($p = .017$). Prophylactic fenestration was performed in 18 (32.7%) dogs. Of them, eight (44.4%) had one PF site, six (33.3%) had two, two (11.1%) had three and two (11.1%) had four PF sites. Prophylactic fenestrations were performed at C2-3 for five (27.8%) dogs, C3–4 for nine (50.0%) dogs, C4–5 for 12 (66.7%) dogs, C5–C6 for three (16.7%) dogs, and C6–7 for five (27.8%) dogs. At least one of the PF sites was located at an adjacent disc to the C-IVDE site in 16 (88.9%) dogs. Distant single PF sites, two intervertebral disc spaces away from the VS site, were performed for two (11.1%) dogs. These sites were degenerated and mildly protruding into the vertebral canal, and the

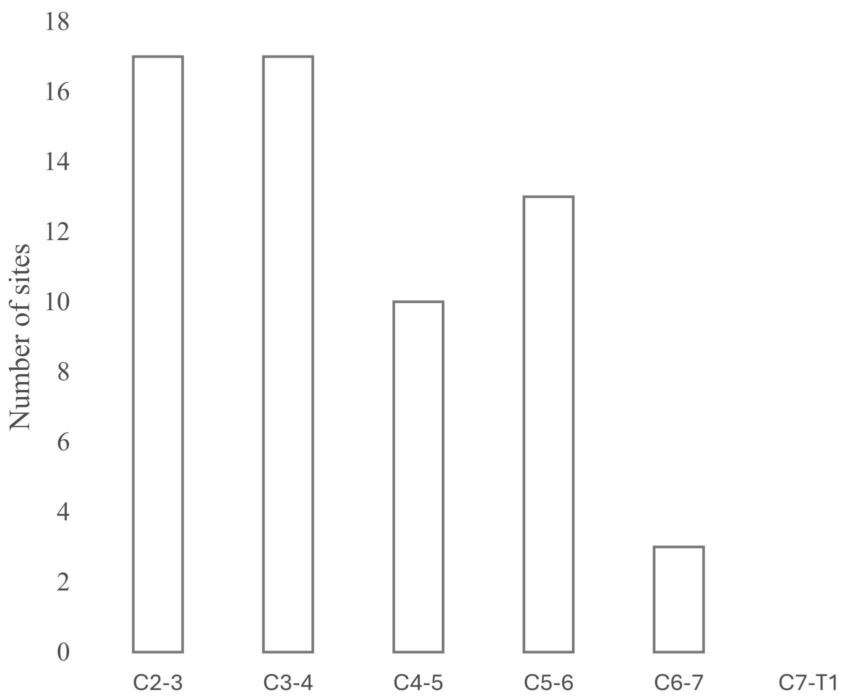

FIGURE 1 Distribution of cervical intervertebral disc extrusion (C-IVDE) sites at first presentation.

same surgeon responsible for these cases elected to perform PF, despite the adjacent intervertebral discs appearing intact. The fenestration was performed with a blade in 13 dogs (72.2%), with a pneumatic drill in four dogs (22.2%) and the technique was not documented in one (5.6%) remaining dog. Postoperative MRI were performed on 14/55 (25.5%) dogs. Postoperative MRI studies were systematically asked by the clinician in charge of these cases.

3.4 | Complications

Perioperative complications at the time of the first surgery occurred for 10 (18.2%) dogs. However, no major complication, as defined in the Materials and Methods, was documented. Complications recorded were mild hemorrhage for 8 (80%) dogs. Two dogs in the non-PF group returned to surgery because of remaining disc material on immediate postoperative MRI. No perioperative complication was reported during the second surgery for these two dogs. There was no significant difference ($p = .838$) in perioperative complication rates between the two treatment groups (16.7% for PF-dogs and 18.9% for non-PF dogs).

One dog, which had a recurrence of C-IVDE confirmed by CT 5 years after the first episode, was euthanized 2 days postoperatively due to bilateral laryngeal paralysis—diagnosed by laryngoscopy—following the second VS surgery. During the first surgery (C-IVDE site: C4–5), the dog was not fenestrated, and no signs of respiratory failure were reported before or after the procedure. At the time of the second surgery, the dog had two VS sites (C2–3 and C3–4) and a single-site PF (C4–5). Because the complication happened after the second surgery, it was not included in the analysis on perioperative complication rates as it would be difficult to determine whether it was the approach on a previously cut site (with potential issues with adherences) for the second VS or the PF that caused the signs.

3.5 | Patient outcome

At the first neurologic examination post-surgery, neurologic grade was available for 44 (80.0%) dogs (Table 2) and for 39 (70.9%) dogs at the time of the first follow-up (Table 3). The median time to the first examination was 14 days after the surgery (range:5-56 days). Between the two groups, there was no significant difference in the repartition of the dogs between those that worsened, those that remained stable or those that improved immediately after VS ($\chi^2 = 1.31$, df $= 2$, $p = .519$) or at 1st follow-up ($\chi^2 = 1.75$, df $= 2$, $p = .416$).

3.6 | C-IVDE recurrence(s)

Clinical signs compatible with recurrence were reported in 14 (25.4%) dogs. A total of 13 (92.8%) had suspected recurrence and one (7.2%) dog had a recurrence confirmed by MRI. Neurologic grade at recurrence was available for 11/14 (78.5%) dogs. Of these, seven dogs (63.6%) were grade 1 and four dogs (36.4%) were grade 2. For the three (27.3%) dogs remaining, there were ambulatory according to the owners. Mean time between first surgical episode and first recurrence was 657 days (range: 127–1386 days, median: 759 days). There was no recurrence reported in the PF group whereas 14/37 (37.8%) dogs in the non-PF group had at least one recurrence

TABLE 2 Distribution of dogs neurologic status compared to presurgery at the postoperative neurologic examination ($n = 44$).

	Improved	Stable	Degradation	Total
PF group	5 (35.7%)	8 (57.1%)	1 (7.2%)	14
Non-PF group	6 (20.0%)	22 (73.3%)	2 (6.7%)	30
Total	11	30	3	44

Abbreviations: Non-PF, no prophylactic-fenestration group; PF, prophylactic-fenestration group.

TABLE 3 Distribution of dogs' neurologic status compared to presurgery at the first follow-up (median: 14 days; range: 5–56 days) neurologic examination ($n = 39$).

	Improved	Stable	Degradation	Total
PF group	6 (60.0%)	2 (20.0%)	2 (20.0%)	10
Non-PF group	17 (58.6%)	10 (34.4%)	2 (5.0%)	29
Total	23	12	4	39

Abbreviations: Non-PF, no prophylactic-fenestration group; PF, prophylactic-fenestration group.

TABLE 4 Influence of different variables on recurrence rate.

Independent variable	LR X^2	Df	*p*-value
PF	13.32	1	**<.001**
Breed	16.62	16	.411
Weight status	0.85	1	.355
Evolution type	1.30	2	.522
Age	0.07	1	.792
Disc C2–3	0.05	1	.826
Disc C3–4	0.05	1	.826
Disc C4–5	0.06	1	.805
Disc C5–6	0.48	1	.488
Disc C6–7	1.02	1	.273
Corticosteroids post-surgery	0.06	1	.813
NSAIDs post-surgery	0.05	1	.821

Note: *p*-values < .05 are considered significant and identified in bold characters.
Abbreviations: Df, degree of freedom; LR, likelihood ratio test; NSAIDs, non-steroidal anti-inflammatory drugs; PF, prophylacticfenestration.

($p < .01$). Medical management was provided for all the 14 dogs with recurrent clinical signs of C-IVDE, and it was successful in 13/14 (92.9%) dogs. No other factors (breed, age at admission, onset of clinical sign, BCS, extrusion site, use of non-steroidal anti-inflammatory drugs or corticosteroids post-surgery) were associated with recurrence (Table 4). A total of 49 (89.1%) owners were successfully reached for a telephone interview. For the six (10.9%) owners who could not be contacted, follow-up data were extracted from the available medical records. The median follow-up time was 1380 days (range: 365-2777 days). Follow-up time differed ($p < .001$) between the PF group (median: 798 days; range: 372-2777 days) and the non-PF group (median: 1872 days; range: 365-2667 days).

4 | DISCUSSION

In our study, there was no recurrence reported in the PF group whereas 37.8% dogs in the non-PF group had at least one suspected or confirmed recurrence, which suggest that PF of degenerated discs (or mineralized on CT) might have a protective effect against C-IVDE recurrence. Although the duration of surgery was significantly longer in the PF group, no significant difference in the perioperative complication rates was observed between the two treatment groups at the time of the first surgery.

Our study population was composed of a mix of small dog breeds, with the first surgical C-IVDE episode being similar to those previously reported in the literature in terms of age, bodyweight, BCS, lesion localization and clinical signs. Dachshunds were overrepresented, a finding consistent with previous studies,[16,18,34,35] but French Bulldogs and Beagles are also frequently reported as affected breeds.[13,17,36,37] The 25% RR for C-IVDE observed in our study is comparable to that reported for similar dog populations, where clinical signs of recurrence have been documented in 8% to 64% of dogs.[13,15,16,18] French Bulldogs have been shown to have a higher risk of C-IVDE recurrence, with RR reaching as high as 47%–51%,[13,14] in comparison to some breeds such as the Yorkshire Terrier that have a lower RR.[38] In our study, breed was not associated with a higher RR. Nevertheless, as recommended for T-IVDE,[29] breed—especially chondrodystrophic dogs—should likely be considered in the decision for PF in the cervical spine.

Our results suggest that PF may have a protective effect against clinical recurrences of C-IVDE. These findings differ from those of a recent retrospective study that evaluated recurrences and risk factors for T-IVDE and C-IVDE, including prophylactic disc fenestration, in 127 French Bulldogs.[14] In that study, no statistical differences were found in RR between fenestrated and non-fenestrated dogs, for both C-IVDE and T-IVDE. However, only 17 out of the 127 dogs (13.4%) included were fenestrated, with four dogs having C-IVDE, which may not be sufficient to draw a definitive conclusion. Moreover, the criteria or technique for PF were not specified. To our knowledge, this is the only published study assessing the effect of PF on C-IVDE recurrences.[14] Our results, however, are consistent with those reported for T-IVDE, where RR without PF range from 2.7% to 41.7%, compared to 0% to 24.4% in PF dogs.[4–6] These RRs vary considerably between these studies due to several factors, including study design, definition of recurrence, surgical techniques, number of PF procedures performed, differences in study populations, and variations in follow-up times. Although the comparison is complicated by these factors, PF appears to reduce the RR for T-IVDE. The prevalence of second disc extrusions in fenestrated discs of the thoraco-lumbar region has been shown to be 26.2 times lower than non-PF discs in another study.[11] However, the absence of a control group in that study limits the strength of its conclusions. In our study, although the number of dogs was quite low, we included both PF and non-PF dogs enabling a more direct comparison. Our selection criteria for PF sites were based on disc degeneration or mineralization, rather than the selection of a specific adjacent site. In a retrospective study where no PF was performed after the first VS, the recurrence site tended to be one adjacent disc in dogs that experienced recurrence following the initial C-IVDE surgery.[15] Most of the dogs in our study had PF at one of the adjacent sites at least. If adjacent sites are indeed predisposed to recurrences, this could have contributed to our low RR. Further studies would be useful in determining whether systematic PF of adjacent sites could reduce RR. Another possible explanation for the absence of recurrence in our PF group is that the C2–3 and C3–4 sites are usually the most involved in C-IVDE.[2,16,18,36,39] Although these sites were not systematically fenestrated, they were fenestrated in 30% and 50% of PF dogs, respectively. Therefore, by targeting the intervertebral disc space frequently responsible for C-IVDE, we may have reduced the risk of recurrence.

No association of recurrence with age at first episode was made in our study, which is similar to what is most reported in the literature.[6,8,10] However, in one study,[14] French Bulldogs with a first episode of IVDD ≤3 years seem to be prone for both total- and cervical-recurrences. More than half of the recurrences occurred within the first 12 month (median) after the first episode of IVDE. This raises the question about the use of PF in younger dogs more prone to recurrence, especially in breeds having a higher RR.

No major perioperative complications were observed in our study during and after the first surgery. If severe adverse events have been reported after VS surgery, their incidence remains low.[37] Complications are more likely related to the VS approach itself than to the PF. Others risks factors such as surgeon experience and caudal C-IVDE sites, may also play a role.[37] In our study, the dog that developed laryngeal paralysis underwent PF only during its second VS surgery. The link between this complication and the PF procedure alone remains uncertain for several reasons. First, during the second episode, two C-IVDE sites were surgically treated, while only one site underwent PF, suggesting that laryngeal paralysis may be more related to the two VS approaches than to the PF itself. Additionally, this was a second intervention performed 5 years after the initial episode, and surgery on modified tissues could have contributed to this complication, making the procedure more challenging. Finally, laryngeal paralysis was bilateral, raising the possibility that the condition may not have been solely caused by the second VS. Pre-existing unilateral paralysis may have gone unnoticed before surgery. Neurologic degradation after fenestration has been reported but no difference between PF and non-PF dogs has been found yet,[40–43] which is consistent with our results. Vertebral subluxation and luxation[11] or discospondylitis[42,44] were not observed. A recent study showed no association between PF and alternative diagnoses being responsible for neurologic deterioration after VS.[45] Complications after PF for T-IVDE were noted only in 0.01% of a large number of dogs in various studies,[46] which is a low rate compared to the reported risk ratio of recurrence. Although these complications are rarely fatal, the risk of euthanasia due to recurrence is likely much higher, as some owners may choose for this option when faced with a recurrence of C-IVDE. Based on a telephone follow-up on patient treated for T-IVDE, 15.8% of the owners reported that their dog had a recurrence and 44% of them elected for euthanasia.[6] Therefore, even if more studies are needed, as mentioned by the latest consensus for acute T-IVDE,[29] the risk of complications might not be a sufficient reason to not perform PF.

Prophylactic fenestration was significantly associated with an increased surgery duration of approximately 40 min. While PF has been associated with a potential reduced recurrence risk, this benefit must be weighed against potential complications caused by this additional surgical time. Prolonged anesthesia has been linked to a poorer prognosis in paraplegic T-IVDE dogs without deep pain perception,[47] and the risk of wound infection increases by 30% for each additional hour of anesthesia.[28] Comparing C-IVDE cases in dogs is challenging since, as observed in our study, most affected dogs remained ambulatory, and deep pain negative cases are extremely rare in C-IVDE. Basic knowledge of ASA classification, or physical status score established by the American Society of Anesthesiologists (ASA), might help also to decide whether PF is safe for a given patient, taking in consideration that the anesthesia risk increases markedly for patients that have a >3 ASA status and being riskier for obese and old patients, as well as brachycephalic breeds.[48–52] More anecdotally, while PF prolongs surgery time, it seems unlikely that this small increase in time impacts the overall cost of the procedure. Therefore, financial considerations should not be a primary argument against PF, especially when considering the potential cost of another surgery in case of a recurrence and the small risk of complication associated with PF.

The limitations of this study include its retrospective design, the small number of recurrences, the lack of advanced imaging to confirm the site of recurrence in suspected cases, and the difference in the duration of follow-up, all of which should be considered when interpreting the results. Additionally, the small sample size of our population may have resulted in a type II error, potentially limiting the statistical power of the test. Also, advanced imaging was not performed in most cases to determine precisely the site of recurrence. The lack of further diagnostics may be explained by the fact that recurrences responded well to medical management, or by owners' concerns about the costs of additional investigations. Our RR might have been overestimated, as other causes of myelopathy, such as discospondylitis or myelitis, can produce clinical signs similar to those of C-IVDE and may have been mistaken for a recurrent episode. Additionally, some discopathies, such as acute non-compressive nucleus pulposus extrusion, could have been influenced by the PF procedure. However, it would be unlikely that myelitis or discospondylitis would have responded so well to medical management like our cases did and acute non-compressive nucleus pulposus extrusion tend to be associated with some type of trauma or strenuous exercise, which were not reported in our recurring cases. Nevertheless, systematic advanced imaging, ideally MRI, when recurrence is suspected, would have been needed to exclude alternative diagnoses. However, selecting only dogs that had advanced imaging, may have inadvertently selected another population of dogs with more severe clinical signs. These might not reflect the whole population of dogs affected by recurrent C-IVDE. Only one dog underwent surgery after a recurrence in our study population. The difference of follow-up between PF and non-PF dogs could be explained by the fact surgeons that routinely fenestrate arrived later in one of the hospitals, meaning that PF dogs tended to be recruited later in the study period. However, given the fact that around 80% of C-IVDE recurrences happen within 2 years after the first episode,[14,15] it seems unlikely that many C-IVDE recurrences were missed in our study, as the mean follow-up time was greater than 2 years for both PF and non-PF dogs. More dogs in the non-PF group had a follow-up period greater than 2 years, which may have led to a mild underestimation of the RR in the PF group. Another limitation is that follow-up evaluations for suspected recurrences were not systematically conducted at the hospitals involved in the study. As a result, subtle or mild neurologic deficits may have gone undetected, making objective neurologic grading difficult. Encouraging owners to provide follow-up videos of their dog's gait could have allowed for a more objective assessment of residual ataxia and represents a potential improvement for future studies. In term of surgery duration, the PF technique used might have had an effect, but there were too few of the same numbers of PF for each technique to compare them. Also, the number of PF performed was not standardized, which might make the comparison with future studies difficult. The number of PF may play a role on RR and surgical time, but our sample size was too small to draw conclusions.

In conclusion, PF during a first VS seemed to decrease the RR for C-IVDE without being associated with a higher rate of perioperative complications. Further research, and especially prospective randomized studies are needed to comprehensively evaluate the procedure's potential complications and long-term outcomes.

AUTHOR CONTRIBUTIONS

As per the International Committee of Medical Journal Editors (ICMJE) definition of authorship, all authors brought substantial contributions to the conception/design of this project and the acquisition of data, drafted and/or revised it critically for important intellectual content, approved the final version to be published, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Berthomé C, DVM, Castel A, DVM, MSc, DACVIM (Neurology), and Gagnon D, DVM, DVSc, DACVS (Small Animal) also actively participated in the statistical analysis and interpretation of the data with our statistician, Juette T, PhD.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest related to this manuscript.

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