Comparison of the effect of single-site and multiple-site disk fenestration on the rate of recurrence of thoracolumbar intervertebral disk herniation in dogs

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Objective—To prospectively assess whether multiple-site disk fenestration decreases the incidence of recurrent thoracolumbar intervertebral disk herniation (IVDH), compared with single-site disk fenestration, in small-breed dogs treated for IVDH.

Design—Randomized controlled clinical trial.

Animals—207 client-owned dogs.

Procedures—Dogs undergoing decompressive surgery of the spinal cord because of thoracolumbar IVDH between 2001 and 2004 were randomly assigned to receive single-site disk fenestration at the level of surgical decompression (n = 103) or multiple-site disk fenestration of all disks from T11 through L4 (104). Follow-up consisted of complete reevaluation of patients, telephone surveys, and further surgery if signs indicative of recurrence occurred.

Results—189 dogs were available for long-term follow-up: 95 dogs in the single-site disk fenestration group and 94 in the multiple-site disk fenestration group. Twenty-four dogs developed 28 confirmed episodes of recurrent thoracolumbar IVDH. The rate for first-time recurrence was 12.7% (24/189). First-time recurrence rates for single- and multiple-site disk fenestration groups were 17.89% (17/95) and 7.45% (7/94), respectively. Dogs undergoing single-site disk fenestration were significantly more likely to have recurrent thoracolumbar IVDH than were dogs undergoing multiple-site disk fenestration. Disk mineralization at the time of first surgery was associated with recurrence, and 87.5% (21/24) of recurrences occurred at a disk space adjacent to or 1 disk away from the initial lesion. Regardless of disk fenestration group, 22 of 24 (91.7%) recurrences occurred at a nonfenestrated disk space.

Conclusions and Clinical Relevance—Multiple-site disk fenestration decreased the rate of recurrent IVDH in small-breed dogs, compared with the use of single-site disk fenestration. (J Am Vet Med Assoc 2011;238:1593–1600)

Thoracolumbar IVDH is a common surgical disease of small and chondrodystrophic breeds. Surgical decompression with removal of extruded disk material is a well-accepted treatment for patients with any severity of clinical signs.1–6 Fenestration of the affected disk space at the time of decompressive surgery of the spinal cord is recommended to prevent continued extrusion of degenerate disk material through the ruptured annulus fibrosus in the early postoperative period.1,4–6 A recent study7 in which magnetic resonance imaging was repeated immediately af-

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Abbreviations

CI Confidence interval
IVDH Intervertebral disk herniation
OR Odds ratio
OVCHSC Ontario Veterinary College Health Sciences Center

ter and at 6 weeks after surgery confirmed further IVDH at the site of surgery in 6 of 10 dogs that did not undergo fenestration of the affected disk space at the time of surgical decompression. Three of 6 patients had clinical signs (pain, paresis, or both) consistent with the recurrent extruded disk material, as observed on magnetic resonance images.8 Early recurrences reportedly occur within 4 to 6 weeks of surgery and are generally related to extrusion of the nucleus pulposus at the site of initial IVDH.9–11

The efficacy of prophylactic disk fenestration to prevent future herniation at nonaffected disk spaces remains controversial. Published information suggests recurrence rates of 0% to 24.4% with prophylactic disk fenestration12–17 and 2.67% to 41.7% without prophylactic disk fenestration.18–19 Retrospective evaluations have shown that late recurrent IVDH occurs at a mean time of 8 to 14
months after the first surgery and within 36 months of the first event.10–12,19,20 Recurrences occur at a new disk space in 88% to 100% of dogs,10,11,19 and > 70% of recurrences occur in a region that could have been readily fenestrated during the first surgery.10 The most recent retrospective studies report recurrence rates of 4.4% (confirmed) in a population of dogs that mostly underwent prophylactic disk fenestration11 and 19.2% (suspected and confirmed) in dogs without prophylactic disk fenestration.20 However, the former study11 also revealed that 13.8% of dog owners reached by telephone follow-up reported that their dog developed signs compatible with recurrent IVDH and were treated elsewhere and that 44% of these dogs were ultimately euthanized for suspected recurrence of IVDH.11 This highlights the lack of follow-up as a major limitation to retrospective studies and emphasizes the need to decrease the rate of recurrence if possible. Arguments for not performing disk fenestration include possible surgical complications,7,11,12,16,21 increased anesthetic and surgical times,6 and increased cost to the owners.6 The purpose of the study reported here was to prospectively assess whether multiple-site prophylactic disk fenestration decreases the incidence of recurrent thoracolumbar IVDH, compared with single-site disk fenestration, in small-breed dogs treated for IVDH.

Materials and Methods

This study was performed in accordance with the guidelines of the University of Guelph Animal Care Committee. With owner consent, small-breed dogs admitted to the OVCHSC for suspected thoracolumbar IVDH were enrolled in this study. The following data were collected: age, sex, breed, history of previous episodes of signs of back pain or neurologic deficits, duration of clinical signs, whether the neurologic signs were stable or continued neurologic deterioration was noted, preoperative neurologic grade, radiographic thoracolumbar disk mineralization, site and side of myelographic lesion, surgical decompression technique used and its location along the vertebral column (site and side), subjective assessment of the amount (small, moderate, large, or very large) and texture (soft, firm, mineralized, or gelatinous) of the extruded disk material removed from the surgery site and at each fenestration site, complications associated with surgery (and more specifically with disk fenestration), postoperative neurologic grade, number of days between surgery and discharge, neurologic grade at discharge, neurologic grade at in-hospital reevaluation, neurologic grade at telephone follow-up, whether recurrence occurred after recovery from the initial surgery, the time between surgery and recurrence, and, for confirmed recurrences, the results of the additional diagnostic evaluation and surgery as already listed. Dogs were excluded from the study if they had previously undergone surgery for IVDH or if the owners did not intend to pursue surgical treatment.

Neurologic grade was classified as 1 to 5 on the basis of a previously described scoring system11,12,20: grade 1 = sign of pain only, grade 2 = ambulatory paraparesis, grade 3 = nonambulatory paraparesis, grade 4 = paralysis, and grade 5 = paralysis with loss of nociception. Dogs assessed as clinically normal were assigned a grade of 0. All dogs received a complete neurologic evaluation followed by surgical decompression to remove the extruded disk material. Prior to surgery, and with owner consent, dogs were randomly assigned to 1 of 2 groups: group 1, single-site disk fenestration (standard surgical decompression and disk fenestration of the herniated site only) or group 2, multiple-site disk fenestration (surgical decompression and fenestration of all disks from T11 through L4). The randomization list was generated in advance by creating 210 identical slips of paper marked with each fenestration group, thoroughly shaken in a box, and manually drawn 1 at a time without replacement. Dogs were scheduled for neurologic assessment at least once 2 to 12 weeks following surgery to determine the extent of neurologic recovery and to provide a postoperative baseline in dogs with recurrence. Dogs deemed to have completely recovered at the time of reevaluation were not reevaluated unless signs of recurrence occurred. An effort was made to reevaluate dogs with residual deficits until full recovery or a stable neurologic grade was documented. Owners were asked to return for evaluation as soon as possible if any signs consistent with a recurrence were observed. All neurologic assessments and diagnostic procedures were performed by the clinicians on duty at the time of admission. Telephone follow-up was also performed on an annual basis to document any recurrence not reported to the staff of the OVCHSC and to determine whether the dogs had any residual signs of back pain or neurologic deficits.

For the purpose of this study, recovery from the initial surgery was defined as being able to walk without assistance (neurologic grade of 2 or lower) as assessed by reevaluation at the OVCHSC, by the referring veterinarian, or by telephone follow-up with the owner. Suspected recurrence was defined as a recurrence of neurologic deficits or worsening of residual deficits after recovery from the initial surgery. In keeping with previously published studies,11,20 dogs with signs of recurrent back pain alone (grade 1) that did not undergo a complete reevaluation were not included in the suspected recurrence group in this study. When signs of recurrence developed, a neurologic evaluation was performed, and with owner consent, a complete diagnostic evaluation was repeated to document the presence and location of spinal cord compression. If a surgical lesion was detected, surgical decompression was performed to remove the extruded disk material and to confirm recurrence for the purpose of the study. Suspected recurrences included dogs that reportedly had signs of recurrence but did not return to the OVCHSC for reevaluation as well as dogs that were admitted with recurrent neurologic deficits but for which the owner declined a complete diagnostic reevaluation or requested euthanasia. When recurrence rates were evaluated, follow-up information for dogs in each fenestration group was considered as follows: all dogs with at least a single follow-up examination, all dogs with at least an 18-month (540-day) follow-up period, all dogs with at least a 24-month (720-day) follow-up period, and all dogs with at least a 36-month (1,080-day) follow-up period. When dogs were admitted more than once for recurrence, only the first recurrence was included in the statistical analysis.
Statistical analysis—All statistical analyses were performed by a statistician (WCS) using an in-house statistical package and a commercial statistical package. A Fisher exact test was used to compare between fenestration groups regarding sex, breed, duration of clinical signs, presence of disk mineralization at the time of diagnosis, affected disk space (site), neurologic recovery score, and recurrence. A Mann-Whitney-Wilcoxon test was used to compare age, previous episodes, neurologic grade at admission, days between surgery and discharge from hospital, and neurologic grade at discharge, recheck evaluation, and telephone follow-up between fenestration groups. A Wilcoxon signed rank test was used to test for change in neurologic grade between time points. Age, sex, breed (Dachshund), history of previous episodes, neurologic grade at admission, presence of disk mineralization at the time of first surgery, and affected disk space were assessed as confounding variables by use of exact conditional logistic regression (with the exact option and the score statistic) to test for any interaction between these variables and fenestration group and to adjust for possible confounding variables. All ORs reported are conditional maximum likelihood estimates with an exact 95% CI computed by use of the method of Sterne. For statements concerning a single proportion, binomial tests were applied, proportions were estimated, and exact Sterne CIs were computed. A value of $P < 0.05$ was considered significant.

Results

Two hundred seven dogs were entered in the study between April 2001 and September 2004. Of these, 103 dogs were randomized to the single-site disk fenestration group ( herniated disk site only), and 104 dogs were randomized to the multiple-site disk fenestration group (from T11 through L4). Dogs from various small and chondrodystrophic breeds were enrolled in this study; of the 207 dogs, there were 97 (46.9%) Dachshunds, 20 (9.7%) Bichon Frisé, 18 (8.7%) Shih Tzu, 18 (8.7%) Cocker Spaniels, 10 (4.8%) Miniature Poodles, 7 (3.4%) Beagles, 7 (3.4%) Lhasa Apso, 6 (2.9%) Pekingese, 2 (0.9%) Maltese, 6 (2.9%) terrier crosses, and 16 (7.7%) small-breed crosses. There was no significant ($P = 0.63$) difference in breed distribution between fenestration groups. More specifically, Dachshunds were evenly distributed between fenestration groups, with 50 randomized to the multiple-site disk fenestration group and 47 randomized to the single-site disk fenestration groups ($P = 0.781$; OR = 1.103; CI = 0.629 to 1.908). Dogs ranged in age from 1 to 13 years (mean, 5.90 years; median, 5 years). There were 80 (39%) females (10 sexually intact and 70 spayed) and 127 (61%) males (25 sexually intact and 102 castrated). No age ($P = 0.11$) or sex ($P = 0.776$) differences were found between fenestration groups (Table 1).

Nineteen of the 207 (9.2%) dogs had a history of neurologic dysfunction of < 12 hours, 73 (35.3%) dogs had signs for 12 to 48 hours, 63 (30.4%) dogs had signs for 2 to 5 days, and 52 (25.1%) dogs had signs for more than 5 days. Fifty-two of the 207 (25.1%) dogs had a history of 1 to 3 prior incidents compatible with IVDH that were treated medically, and 15 (7.2%) dogs had an unknown history. There was no significant difference in duration of clinical signs ($P = 0.057$) and in the number of previous episodes ($P = 0.20$) between fenestration groups. Signs related to IVDH were categorized according to the neurologic grade: grade 1 ( single-site group, 3 dogs; multiple-site group, 2 dogs), grade 2 (single-site group, 42 dogs; multiple-site group, 37 dogs), grade 3 (single-site group, 18 dogs; multiple-site group, 35 dogs), grade 4 (single-site group, 30 dogs; multiple-site group, 24 dogs), and grade 5 (single-site group, 10 dogs; multiple-site group, 6 dogs). The neurologic grades at admission were not significantly ($P = 0.781$) different between fenestration groups (Table 1).

Mean and median times between hospital admission and surgery were 0.77 days and 1 day (range, 0 to 7 days), respectively; there was no significant ($P = 0.584$) difference between fenestration groups. Radiographic evidence of disk mineralization along the thoracolumbar portion of the vertebral column was observed for 128 of the 207 (61.8%) dogs, whereas 79 (38.2%) dogs had no evidence of disk mineralization at the time of surgery. The distribution of dogs with or without thoracolumbar disk mineralization was not significantly ($P = 0.23$) different between fenestration groups.

Myelography was performed in all dogs except for 2 dogs that underwent magnetic resonance imaging. One myelogram was not diagnostic; in this dog, the surgical approach was based on clinical and radiographic findings. Surgical decompression and removal of extruded disk material confirmed the site of IVDH as T11-12 in 31 of the 207 (15%) dogs, T12-13 in 59 (28.5%) dogs, T13-L1 in 52 (25.1%) dogs, L1-2 in 27 (13%) dogs, L2-3 in 25 (12.1%) dogs, and L3-4 in 6 (2.9%) dogs. There was no significant ($P = 0.20$) difference in the distribution of affected disk spaces between fenestration groups. In 7 of the 207 (3.4%) dogs, the extruded disk material and the surgical decompression extended between April 2001 and September 2004. Of these, 103 dogs were randomized to the single-site disk fenestration group ( herniated disk site only), and 104 dogs were randomized to the multiple-site disk fenestration group (from T11 through L4). Dogs from various small and chondrodystrophic breeds were enrolled in this study; of the 207 dogs, there were 97 (46.9%) Dachshunds, 20 (9.7%) Bichon Frisé, 18 (8.7%) Shih Tzu, 18 (8.7%) Cocker Spaniels, 10 (4.8%) Miniature Poodles, 7 (3.4%) Beagles, 7 (3.4%) Lhasa Apso, 6 (2.9%) Pekingese, 2 (0.9%) Maltese, 6 (2.9%) terrier crosses, and 16 (7.7%) small-breed crosses. There was no significant ($P = 0.63$) difference in breed distribution between fenestration groups. More specifically, Dachshunds were evenly distributed between fenestration groups, with 50 randomized to the multiple-site disk fenestration group and 47 randomized to the single-site disk fenestration group ($P = 0.781$; OR = 1.103; CI = 0.629 to 1.908). Dogs ranged in age from 1 to 13 years (mean, 5.90 years; median, 5 years). There were 80 (39%) females (10 sexually intact and 70 spayed) and 127 (61%) males (25 sexually intact and 102 castrated). No age ($P = 0.11$) or sex ($P = 0.776$) differences were found between fenestration groups (Table 1).

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* n = 200 dogs. 1n = 162 dogs. 2n = 158 dogs.
over 2 (5 dogs) or 3 (2 dogs) disk spaces, and the exact site of herniation could not be confirmed surgically. These 7 dogs were from the multiple-site disk fenestration group. Surgery was performed on the right side in 49.8% (103/207) of dogs, on the left in 42% (87/207) of dogs, and bilaterally in 8.2% (17/207) of dogs in order to retrieve the herniated disk material. All dogs were confirmed to have IVDH by removal of extruded disk material from the vertebral canal as assessed by visual inspection at the time of surgery.

Manual blade fenestration was performed in 171 of 207 (82.6%) dogs (single-site group, 88 dogs; multiple-site group, 83 dogs), power-assisted fenestration was performed in 32 (15.5%) dogs (single-site group, 15 dogs; multiple-site group, 17 dogs), and a combination of both disk fenestration techniques was performed in 4 (1.9%) dogs (all from the multiple-site disk fenestration group). There was no significant ($P = 0.702$) difference in the distribution of disk fenestration techniques between fenestration groups.

Thirty-one of 207 (15%) dogs (single-site group, 11 dogs; multiple-site group, 20 dogs) had an increase in neurologic dysfunction after surgery; compared with neurologic grade before surgery, but the difference was not significant ($P = 0.118$; OR = 0.504; CI = 0.215 to 1.159). Fourteen of the 31 (45.2%) dogs (single-site group, 6 dogs; multiple-site group, 8 dogs) had a worsening of clinical signs but remained within the same neurologic grade (eg, increased ataxia only); there was no significant ($P = 0.783$; OR = 0.743; CI = 0.245 to 2.291) difference between fenestration groups. Seventeen of the 31 (54.8%) dogs had a worsening of their neurologic status postoperatively. Of these, 15 (single-site group, 3 dogs; multiple-site group, 10 dogs) increased by 1 neurologic grade, and 2 dogs (both in the multiple-site disk fenestration group) increased by 2 neurologic grades; the increase in neurologic grade was not significantly ($P = 0.127$; OR = 0.393; CI = 0.129 to 1.511) different between fenestration groups. One dog had a second surgery the following day to remove the extruded disk material that could not be removed at the time of initial surgery because of severe vertebral sinus hemorrhage. Other complications of surgery included difficulty identifying 1 or more disk spaces, making disk fenestration difficult (4 multiple-site disk fenestration–group dogs); hemorrhage from the vertebral sinus (3 single-site disk fenestration–group dogs); hemorrhage from the vertebral artery during disk fenestration (7 multiple-site disk fenestration–group dogs); nerve root trauma causing postoperative abdominal wall weakness (single-site group, 2 dogs; multiple-site group, 2 dogs); and broken curette tip within a disk space (1 multiple-site disk fenestration–group dog). The rate of complication between fenestration groups was not significantly ($P = 0.052$; OR = 0.330; CI = 0.110 to 1.011) different. The mean and median neurologic grades at discharge were 2.36 and 2 (range, 0 to 3), respectively, with no significant ($P = 0.285$) difference between fenestration groups (Table 1).

Five dogs died or were euthanized prior to hospital discharge; 1 died 48 hours after surgery, and 4 were euthanized because of ascending or descending myelomacia or lack of neurologic improvement. The mean and median number of days between surgery and discharge were 3.71 and 3 days (range, 1 to 32), respectively, with no significant ($P = 0.278$) difference between fenestration groups. Two dogs were euthanized within 14 days of discharge for self-mutilation and for lack of neurologic improvement. A total of 11 dogs were not available for recheck evaluation; their owners could not be reached by telephone for follow-up (7 dogs), or the dogs were alive but did not recover the ability to walk without assistance (4 dogs) and were therefore considered lost to follow-up at the time of discharge. One hundred eighty-nine dogs were therefore available for long-term follow-up in this study: 95 dogs in the single-site disk fenestration group and 94 in the multiple-site disk fenestration group. Of these 189 dogs, 27 (14.29%) did not return for reevaluation at the veterinary teaching hospital but did return to the referring veterinary clinic for suture removal and neurologic assessment, and the owners were reached by telephone follow-up over the course of the study. The mean and median neurologic grade at the time of recheck evaluation at the veterinary teaching hospital was 1.4 and 2 (range, 0 to 3), respectively. There was no significant ($P = 0.845$) difference in neurologic grade at recheck evaluation between fenestration groups (Table 1). The neurologic grade at recheck evaluation was significantly ($P < 0.001$) lower than the neurologic grade at discharge. The minimum follow-up time was 14 days (1 dog returned for recheck evaluation and was then lost to follow-up), and the maximum follow-up time was 2,242 days. Mean and median follow-up times were 1,204.6 days and 1,237 days, respectively. The last 3 dogs enrolled in the study had 34- to 36-month follow-up periods. The mean and median neurologic grades at telephone follow-up were 0.51 and 0 (range, 0 to 2), respectively, with no significant ($P = 0.523$) difference between fenestration groups.

Twenty-eight recurrences of thoracolumbar IVDH were confirmed in 24 dogs; only the first recurrences after the initial surgery ($n = 24$) were considered in analyses. The confirmed recurrence rate for this study was 12.7% (24/189; CI = 8.56% to 18.20%); 7 of 94 dogs (7.45%; CI = 3.55% to 14.73%) were from the multiple-site disk fenestration group, and 17 of 95 dogs (17.89%; CI = 11.26% to 27.77%) were from the single-site disk fenestration group. Recurrence rates were significantly different between fenestration groups at all time points (ie, overall and at 18, 24, and 36 months of follow-up; Table 2), with dogs undergoing decompression and single-site disk fenestration being more likely to develop a recurrence than dogs treated with decompression and multiple-site disk fenestration. Overall, dogs from the single-site disk fenestration group were 2.7 (CI = 1.06 to 7.50) times as likely to have thoracolumbar IVDH recurrence as dogs in the multiple-site disk fenestration group. Although lesion location was significantly ($P = 0.042$) related to recurrence, it was not a confounder, nor was there a significant ($P = 0.298$) interaction between fenestration group and lesion location. Although disk mineralization was not significantly ($P = 0.077$) related to recurrence, it appeared to have a confounding effect on the relationship between fenestration group and recurrence. When adjusting for disk mineralization at the time of first surgery, the odds of recurrence for the single-site disk fenestration group increased to 3.2
times (P = 0.015; OR = 3.168; CI = 1.231 to 9.279) the odds of recurrence in the multiple-site disk fenestration group, compared with an OR of 2.7 when not accounting for mineralization. However, a significant (P = 0.094) interaction was not found between disk mineralization at the time of first surgery and fenestration groups. Age was also significantly (P = 0.025; OR = 3.09; CI = 1.117 to 9.535) related to recurrence and appeared to be a confounder on the basis of the change in the OR from 2.7 to 3.1. As age increased, the odds of recurrence decreased by 0.797/1 (CI = 0.642 to 0.968). There was, however, no significant (P = 0.093) interaction between age and fenestration group. Sex (P = 1.0), breed (Dachshund; P = 1.0), history of previous episodes (P = 0.476), and neurologic grade (P = 0.792) were not significantly related to recurrence, and an interaction between these variables and the fenestration groups was not found.

The mean and median neurologic grades at recurrence were 2.67 and 3, respectively (range, 1 to 5). The mean and median neurologic grades for these dogs prior to recurrence were 0.67 and 0, respectively (range, 0 to 2). Recurrences occurred 3 to 51 months after surgery (mean, 16.2 months; median, 11.75 months). Eleven of 24 (45.8%) dogs with recurrences were Dachshunds; the recurrence rate in Dachshunds was not significantly (P = 0.839) higher than the rate in other breeds. All episodes of recurrent IVDH developed at a new disk space. Regardless of fenestration group, 22 of 24 (91.7%; CI = 73.3 to 98.5) dogs developed recurrences of thoracolumbar IVDH at a disk space that had not been fenestrated at the time of decompressive surgery; only 2 of 24 recurrences occurred at a previously fenestrated disk space. The odds of recurrence at a nonfenestrated disk space were approximately 11 times the odds of recurrence at a fenestrated disk space (CI = 2.75 to 65.61).

Twenty-one of 24 (87.5%; CI = 69.0% to 96.5%) recurrences of thoracolumbar IVDH occurred at a site immediately adjacent (10/24) to the first lesion or the last fenestrated disk space or 1 disk space away (11/24). Four of 24 (16.7%) recurrences occurred at L4–5 (3 dogs) or L5–6 (1 dog); all 9 of these dogs were from the multiple-site disk fenestration–group dogs that developed a recurrence of IVDH.

Eighteen of the 24 (75%) dogs that had a documented recurrence had at least 1 mineralized thoracolumbar disk at the time of first surgery; whereas 6 (25%) dogs did not (P = 0.023). Fifteen of the 24 (62.5%) dogs had recurrences at a disk space that was mineralized at the time of first surgery, and 9 (37.5%) had recurrences at a disk space that was not mineralized at the time of surgery (P = 0.307). Four of 24 dogs with 1 recurrence developed a second distinct, surgically confirmed recurrence of thoracolumbar IVDH during the study period; all were from the single-site disk fenestration group. Four dogs also underwent cervical ventral slot decompression for cervical IVDH during the study period. All dogs undergoing surgical decompression for recurrent IVDH recovered the ability to walk without assistance.

In addition to the confirmed recurrences, 45 dogs were evaluated 47 times (19 evaluations at the Ontario Veterinary College and 28 evaluations at the referring veterinary clinic) for suspected recurrence. Thirty-four episodes were not considered possible recurrence because they were related to signs of neck pain (n = 9), signs of back pain that was attributed to multiple myeloma (1), deficits that were deemed to be residual (1), or only signs of mild back pain without neurologic deficits (23 episodes in 21 dogs; 11 episodes in 11 dogs of the single-site group and 12 episodes in 10 dogs of the multiple-site group). The distribution of dogs admitted for reevaluation of signs of pain alone that did not undergo a complete diagnostic evaluation was not significantly (P = 1.0; OR = 1.088; CI = 0.432 to 2.724) different between fenestration groups. Eleven reevaluations were for recurrence of signs of back pain and mild ataxia. In 3 of these evaluations, myelography was performed but revealed no evidence of spinal cord compression. In the other 8 evaluations, recurrence was suspected but not confirmed because of the low neurologic grade and because the owners declined a complete diagnostic evaluation for mild neurologic dysfunction. Two additional dogs were euthanized without a complete diagnostic evaluation at the owner’s request for suspected IVDH recurrence causing recurrent paraplegia; a postmortem examination was not performed. Overall, 10 of the 189 (5.3%) dogs available for long-term follow-up (single-site group, 7 dogs; multiple-site group, 3 dogs) had neurologic deficits consistent with possible recurrent thoracolumbar IVDH but did...
not undergo a complete diagnostic evaluation and were considered as having suspected recurrences that could not be confirmed. The distribution of dogs admitted for suspected recurrence with neurologic deficits that did not undergo a complete diagnostic evaluation was not significantly (P = 0.330; OR = 2.402; CI = 0.621 to 11.084) different between fenestration groups. Inclusion of the 10 suspected but unconfirmed recurrences in the statistical analysis showed that dogs that underwent single-site disk fenestration were more likely to have recurrences, compared with dogs that underwent multiple-site disk fenestration (P = 0.013; OR = 2.824; CI = 1.226 to 6.490). Inclusion of the dogs with confirmed recurrences (24 dogs), those with suspected but unconfirmed recurrences that had neurologic deficits (10 dogs), and those with possible recurrences with signs of back pain only (21 dogs) in the statistical analysis continued to show that dogs that underwent single-site disk fenestration were more likely to have recurrences, compared with dogs that underwent multiple-site disk fenestration (P = 0.025; OR = 2.149; CI = 1.092 to 4.240).

At the time of last telephone follow-up, 40 of the 189 (21.2%) dogs (single-site group, 17 dogs; multiple-site group, 23 dogs) were lost because the owners could not be reached, and 30 (15.9%) dogs (single-site group, 14 dogs; multiple-site group, 16 dogs) were confirmed dead. Twenty-two dogs had died of old age or of issues unrelated to IVDH. Including the suspected recurrences enumerated, 8 dogs were euthanized for a suspected second or third episode of IVDH (6 thoracolumbar and 2 cervical) because of a perceived poor outcome.

Discussion

A previously published retrospective study\textsuperscript{11} revealed a confirmed recurrence rate of 4.4% and an additional unconfirmed recurrence rate of 15.8% obtained via telephone follow-up in dogs with IVDH. In the present study, the overall confirmed recurrence rate was 12.7% (24/189). As we anticipated, the confirmed rate of recurrence increased by providing a financial incentive for reevaluations, repeat diagnostics, and surgical treatment for dogs suspected of recurrence. Although the previously published retrospective study\textsuperscript{11} revealed that fenestration protected disk spaces against herniation, the study failed to show a significant difference between dogs that had undergone multiple-site disk fenestration and those that had undergone single-site disk fenestration. Findings of the present study indicate that dogs undergoing single-site disk fenestration only at the site of herniation at the time of decompressive surgery are significantly more likely to develop subsequent thoracolumbar IVDH (17.89% [17/95]) than are dogs that underwent multiple-site disk fenestration from T11 through L4 (7.45% [7/94]). Inclusion of the unconfirmed recurrences in the analysis supported this also. Moreover, only dogs from the single-site disk fenestration group developed 2 confirmed recurrences of thoracolumbar IVDH. Inclusion of the multiple recurrence events would have increased the overall confirmed recurrence rate to 14.8% and increased the rate of recurrence in the single-site disk fenestration group to 22.11%.

Results of this study support the fact that disk fenestration protects against recurrence at the fenestrated disk space, with only 8.33% (2/24) of recurrences occurring at a previously fenestrated site. In fact, the odds of recurrence at a nonfenestrated disk space were 11 times those of recurrence at a fenestrated disk space. It has been shown that the effectiveness of disk fenestration is governed by the amount of nucleus pulposus removed.\textsuperscript{21} Recurrences at a previously fenestrated disk space are therefore likely related to incomplete removal of disk material from the disk space at the time of fenestration\textsuperscript{17}. This is supported in the present study by the fact that only a small amount of disk material was reportedly removed at these disk spaces at the time of first surgery. Although power-assisted disk fenestration has been shown to result in more effective disk evacuation than manual blade fenestration,\textsuperscript{31} it did not appear to be a factor in the present study.

Similarly to what has previously been reported,\textsuperscript{10,11,20} 87.5% (21/24) of recurrences occurred at a disk space immediately adjacent to the previous lesion or last site of disk fenestration or 1 disk space away. This is likely related to the biomechanical effects of IVDH and disk fenestration on the vertebral column.\textsuperscript{23,26} In the multiple-site disk fenestration group, 4 of the 7 dogs that developed a recurrence of IVDH did so at L4-5 or L5-6. This is of importance because an IVDH at this level can cause lower motor neuron deficits, which may result in a worse prognosis or a longer recovery period.\textsuperscript{27} In addition, surgical decompression at that level poses higher risks of damaging the nerve roots of the lumbar intumescence and is considered more challenging by some surgeons. It is also of importance because the reported incidence of naturally occurring IVDH at L4-5 is between 3.7% and 7%, emphasizing that disk fenestration may actually predispose nonfenestrated, adjacent disks to herniation.\textsuperscript{11,19,20,29} In contrast, disk fenestration of the herniated disk space is recommended at the time of surgery because further IVDH through the damaged annulus fibrosus is common after decompression without disk fenestration.\textsuperscript{9}

Recurrences reportedly occur 18 to 36 months after the first surgery,\textsuperscript{10,12,19,20} and the mean and median follow-up times for the present study were 40 and 41 months, respectively. Sixty-six percent of the dogs enrolled in this study had at least a 36-month follow-up period after surgical decompression. Although recurrences in this study occurred between 3 and 51 months, 21 of 24 recurrences occurred within 34 months (mean, 16.2 months; median, 11.75 months). The authors believe that the follow-up times for this study were appropriate and likely to capture most recurrences. Similar to what has previously been published,\textsuperscript{19} dogs undergoing repeat surgery for recurrent IVDH had a good prognosis and recovered the ability to walk.

None of the signalment and clinical variables tested were found to differ between fenestration groups. Although duration of clinical signs prior to surgery (P = 0.057) might have had an impact on neurologic recovery, it should not have affected recurrence because only dogs that returned to unassisted ambulation were considered for long-term follow-up.

Although a previous retrospective study\textsuperscript{11} revealed that recurrence in Dachshunds is approximately 10
times as likely as in other breeds, this was not observed in the present study. In addition, being a Dachshund was not found to be a confounding variable when assessing for recurrence in this study. Although the data between the 2 studies appear similarly distributed, lack of power as a result of having fewer recurrences in the retrospective study and possibly the uneven distribution between fenestration groups may have affected the results. Two additional studies have also reported conflicting results regarding the possibility that Dachshunds are more likely to develop recurrent IVDH.

Radiographic disk mineralization at the time of surgery has been reported as a risk factor for recurrence. When adjusting for disk mineralization at the time of first surgery in the present study, the odds of recurrence for the single-site disk fenestration group increased to 3.2 times the odds of recurrence in the multiple-site disk fenestration group, compared with 2.7 when not accounting for mineralization. These results, along with the fact that recurrent IVDH tends to occur at adjacent disk spaces and that disk fenestration appears to decrease the risk of recurrent herniation, support the recommendation to fenestrate adjacent mineralized disks at the time of first surgery.

A small percentage of dogs in the present study had an increase in their neurologic dysfunction (reflected by an increase in their neurologic grade) immediately after surgery, compared with that before surgery; most dogs recovered to their preoperative neurologic status within 1 to 5 days after surgery. Clinical deterioration might have been related to surgical trauma, residual hemorrhage, or continued deterioration related to the initial IVDH. Although deterioration caused by disk fenestration cannot be ruled out, statistical analysis does not support this because the rate of deterioration was not significantly different between fenestration groups. Although the rate of complication between fenestration groups was not significantly different (P = 0.052) different, the single-site disk fenestration group appeared less likely to have complications, compared with the multiple-site disk fenestration group. The lack of a significant difference was likely related to a lack of power owing to the low number of complications encountered during the present study. Although a higher rate of surgical complications related to decompressive surgery with multiple-site disk fenestration is concerning, complications encountered in this study were minor, and long-term effects were not identified.

Limitations of this study include the fact that the surgical procedures were performed by several surgeons rather than by a single surgeon. The surgeon’s experience and comfort level with the disk fenestration procedure could have affected the outcome, but the results of this study do not suggest that this was the case. A previously published study revealed that power-assisted fenestration was more effective with approximately 65% of the disk material being removed, compared with only 41% during manual blade fenestration. This theoretically could also have affected our results, but only a small proportion of the affected dogs underwent power fenestration, and these were entered evenly between fenestration groups.

A second limitation was the fact that binding of the neurologists, surgeons, referring veterinarians, and owners to fenestration group was not performed in this study. Although clinician bias cannot be ruled out because formal blinding was not performed in this study, the authors believe that bias is unlikely to have been a factor given that numerous clinicians involved in admitting, managing, and reevaluating the dogs over the course of the study were those on hospital duty at any given time and were not specifically involved in this study or aware of fenestration group assignment.

Although including a third treatment group that received decompression of the affected disk space without any disk fenestration might have been ideal, it was not considered possible in this study because fenestration of the affected disk space has been recommended to prevent early recurrence of IVDH through the ruptured annulus fibrosus and is considered standard of care at the Ontario Veterinary College. For this reason, we opted to compare multiple-site disk fenestration with single-site disk fenestration. The effect of performing no disk fenestration on the rate of late recurrence is unknown.

Finally, comparison of surgical and anesthesia times for each fenestration group was not included in this study. These times vary greatly depending on diagnostic imaging, the number of sites or sides where decompressive surgery is required, vertebral sinus hemorrhage, and surgeon speed. In retrospect, the authors regret not documenting the times required to perform single-site and multiple-site disk fenestration in this study. Although one can anticipate that performing multiple-site disk fenestration increases the anesthetic and surgical times, compared with performing single-site disk fenestration, it is likely that surgeon speed and comfort would also have affected these times. No anesthetic complications were documented in this study.

Telephone follow-up revealed that some dogs were evaluated elsewhere for signs of possible recurrent IVDH rather than returning to the Ontario Veterinary College as requested. The reasons for not returning to the Ontario Veterinary College for suspected recurrence were distance and time constraints along with the lack of severe signs of recurrence. This highlights an additional limitation of using clinical patients in this study. In all, 10 dogs developed signs consistent with recurrent IVDH in this study but did not undergo a complete patient evaluation to confirm it. Two of these dogs had developed severe neurologic deficits consistent with recurrent IVDH for which a complete diagnostic evaluation was recommended but declined by the owners because they did not want their dog to undergo another surgery and recovery period. The other 8 dogs were treated medically because the neurologic deficits were mild or the owners declined a complete patient evaluation. All dogs enrolled in the study were treated according to our standard management practices, and the authors were not comfortable recommending a complete diagnostic evaluation for academic purposes only. Although we cannot confirm whether the 10 suspected recurrences were actual IVDH recurrences, one can assume that the true recurrence rate could be higher than the confirmed rate reported in the study reported here.

An additional 23 reevaluations (in 21 dogs) were for signs of back pain with no neurologic deficits, and

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these dogs did not undergo a complete diagnostic evaluation to rule out recurrent IVDH because of their response to medical treatment or because their owner declined a complete diagnostic evaluation for mild clinical signs. Without a complete diagnostic evaluation, signs of back pain caused by IVDH are difficult to differentiate from other unrelated conditions. On the basis of the fact that 30% to 50% of medically managed dogs with suspected thoracolumbar IVDH are reported to have recurrence,\textsuperscript{11,13,30} one can assume that at least half of the dogs admitted for a single episode of signs of mild back pain that did not undergo a complete diagnostic evaluation did not actually develop recurrent IVDH. In fact, 3 dogs with signs of mild postoperative back pain that underwent myelography and had no compressive lesions were ultimately treated medically in this study. Nevertheless, the even distribution of dogs admitted with signs of back pain alone (single-site group, 11 dogs; multiple-site group, 10 dogs) that did not undergo a complete diagnostic evaluation differs from that of the 24 dogs with confirmed recurrences (single-site group, 17 dogs; multiple-site group, 7 dogs). The reason for this distribution is not clear, but a possible explanation could be that dogs undergoing multiple-site disk fenestration are more likely to develop signs of postoperative back pain and likely warrants further investigation.

The results of this study suggest that the confirmed recurrence rate of IVDH is lower in dogs undergoing decompression and multiple-site disk fenestration, compared with the rate in dogs undergoing decompression and single-site disk fenestration, and recurrence is more frequent in dogs with radiographic evidence of disk mineralization at the time of first surgery. This study also revealed that recurrence occurs more frequently at L4-5 and L5-6 in dogs that undergo multiple-site disk fenestration from T11 through L4, which could lead to lower motor neuron deficits and perhaps a more difficult surgical approach. On the basis of the results of this study, the authors recommend multiple-site disk fenestration of mineralized adjacent disk spaces at the time of first surgery.

\textbf{References}