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STANDARD ARTICLE

Comparison of surgical and conservative treatment of hydrated nucleus pulposus extrusion in dogs

Jasmin Nessler[1] | Cornelia Flieshardt[2] | Julia Tünsmeyer[1] | Ricarda Dening[1] | Andrea Tipold[1]

[1]Department of Small Animal Medicine and Surgery, University of Veterinary Medicine, Hannover, Germany
[2]Department of neurology Clinic of Small Animals, Posthausen, Germany

Correspondence
Jasmin Nessler, Clinic for Small Animals, University of Veterinary Medicine Hannover, Foundation, Neurology Buenteweg 9, 30559 Hannover, Germany.
Email: jasmin.nessler@tiho-hannover.de

Background: Whether compressive cervical myelopathy caused by hydrated nucleus pulposus extrusion (HNPE) in dogs should be treated surgically or conservatively has been debated. Only 1 recent study has contradicted the former predominant reports of surgical treatment for HNPE.

Hypothesis and method: Single center retrospective study to compare the outcome of client-owned dogs with HNPE after decompressive surgery or conservative treatment.

Animals: Thirty-six dogs diagnosed with HNPE confirmed by magnetic resonance imaging (MRI).

Results: Eighteen of 36 dogs underwent surgery whereas 18 dogs were managed conservatively including cage rest and physiotherapy. The most common affected intervertebral disc space was C4-5. In 3 dogs, HNPE was diagnosed at the level of T13-L1. Median time to regain ambulation was 6.6 days (range, 0-28 days) after surgery and 5.9 days (range, 0-15 days) with conservative management (P = .37).

Only the length of a potential intramedullary lesion in cervical HNPE detected by MRI had an influence on the prognosis to gain ambulatory status in a time period of ≤9 days (P = .0035) and on short-term survival (P = .0011).

Conclusions and clinical importance: Conservative management of HNPE in the cervical as well as in the thoracolumbar region represents a reasonable alternative to surgery, showing similar favorable outcome.

KEYWORDS
canine, hydrated nucleus pulposus extrusion, outcome, treatment

1 | INTRODUCTION

Several different patterns of intervertebral disc herniation (IVDH) are described in veterinary literature: compressive nucleus pulposus extrusion (Hansen type I) and annulus fibrous protrusion (Hansen type II),[1] as well as acute noncompressive nucleus pulposus extrusion (AHNPE).[2] In recent studies, an extrusion of hydrated nucleus pulposus material (hydrated nucleus pulposus extrusion [HNPE]) was described in dogs,[3,4] a disease also known as AHNPE[5] or discal cyst.[6] In this situation, gelatinous to liquid, histologically only partially degenerated disc material causes a compressive myelopathy.[4,7] This contrasts with the extrusion of solid degenerated and frequently calcified nucleus pulposus material present in Hansen type I disc disease.[8] Diagnosis of HNPE is made by magnetic resonance imaging (MRI).[3] The MRI findings are characterized by a ventral extradural spinal cord compression because of material originating from the intervertebral disc space, which is

Abbreviations: CI, confidence interval; h, hour; HNPE, hydrated nucleus pulposus extrusion; IV, intravenous application; kg, kilogram; mg, milligram; MR, magnetic resonance; MRI, magnetic resonance imaging; PO, per os, oral application; q6h, every 6 hours; q8h, every 8 hours; SC, subcutaneous application; STIR, suppression short tau inversion recovery sequence; T1w, T1-weighted; T2w, T2-weighted.

hyperintense in T2-weighted (T2w) and gradient echo-weighted sequences, hypo- to isointense in T1w and fluid attenuated inversion recovery. Furthermore, the extruded disc material has a characteristic shape, lying midventral and having a "seagull"-like appearance with a bilateral symmetrical bi-lobed dorsal bulging.[3]

Whether or not dogs with HNPE should undergo surgery has been debated[9,10]: Sporadic reports of successful conservative management including analgesia, cage rest, and physiotherapy have been published[3,11–13] whereas the majority of studies describe surgical decompression of the spinal cord.[3,7,12–14] At the time of our study, no evidence supported surgery over conservative management in dogs with HNPE. Recently, another group published a similar study.[15] They could show no significant differences for short-term or long-term outcome between surgical and conservative treatment of HNPE in dogs. To further evaluate the role of conservative treatment in dogs with HNPE, we hypothesized that surgical intervention would not be superior to conservative treatment with respect to outcome and time to functional recovery in dogs with HNPE.

2 | MATERIALS AND METHODS

2.1 | Case selection

Patient data from the Small Animal Clinic of the University of Veterinary Medicine Hannover, Foundation, Germany, from 2012 to 2017 were retrospectively evaluated by the patient administration software "easyVET" (VetZ, Isernhagen, Germany). Neurological examinations of dogs with suspected myelopathy were identified by the search criteria neurolocalization "C1-C5," "C6-T2," "T3-L3," "L4-S1," and "L4-S3." Patient data from 2006 to 2012 were searched for dogs with HNPE evident on MRI with the patient administration software "Anidata" (Comitas Software GmbH, Leipzig, Germany). The search identified an additional 6 dogs with HNPE, but precise numbers on dogs with myelopathy in general could not be obtained for the earlier time point because patient data were not entirely available after the software change in 2012.

Dogs without MRI examination were excluded. The MRI study, the written report, or both were evaluated for the presence of MRI characteristics suspicious for HNPE, which was an extradural spinal cord compression caused by T2w hyper-, T1w iso-, to hypo-intense and well-delineated material originating from the intervertebral disc space.[3] Only dogs with suspected HNPE based on MRI examination were included in the study (Figure 1).

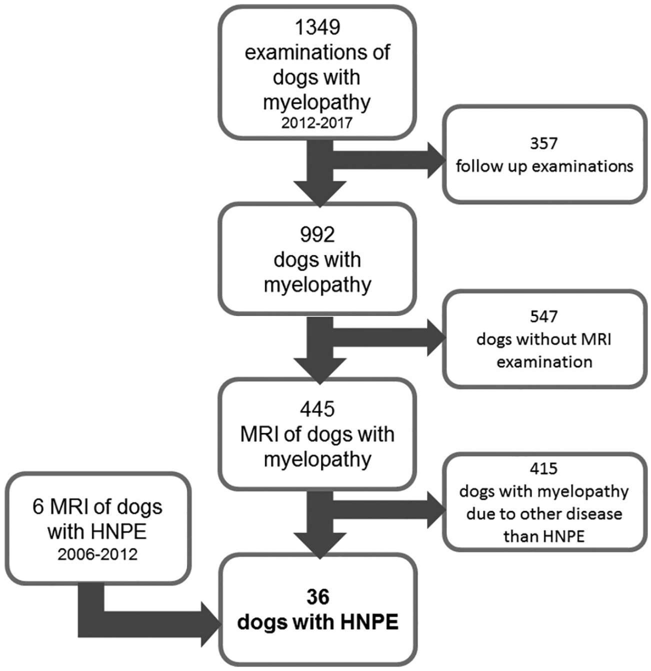

FIGURE 1 Flowchart of patients included into study 1349 examinations of dogs with myelopathy were performed between 2012 and 2017 of which 357 were follow-up examinations. Of the remaining 992 dogs with myelopathy, 445 dogs underwent magnetic resonance imaging (MRI). Dogs without MRI examination were excluded. A total of 415 dogs had other myelopathies than hydrated nucleus pulposus material (HNPE) and were likewise excluded. A search in the former patient management system (2006-2012) identified additional 6 dogs with HNPE

2.2 | Clinical information

Patient data obtained and analyzed included breed, sex, age, weight, time from onset of clinical signs to presentation in the clinic, as well as neurological examination findings including signs of spinal hyperesthesia. Neurological grades were assessed according to Sharp and Wheeler,[1] and graded as spinal hyperesthesia only (grade 1), ambulatory para- or tetra-paresis (grade 2), nonambulatory para- or tetraparesis (grade 3), para- or tetra-plegia with intact nociception (grade 4), and para- or tetra-plegia without nociception (grade 5). If the information was available, the ability to urinate and defecate voluntarily was recoded.

2.3 | Magnetic resonance imaging

Magnetic resonance imaging was performed with a 1.0 T scanner (Magnetom Impact Plus, 1.0 T, Siemens AG Medical Solutions Magnetic Resonance Imaging, Forchheim) or 3.0 T scanner (Achieva, Philips Medical Systems, Best, the Netherlands). Sagittal and transverse T2w and 1 gradient echo sequences of the affected segments of the spinal cord were performed in all cases. The MRI appearance of the HNPE was evaluated for affected intervertebral disc space, maximal cross-sectional spinal cord compression as previously described,[3] signal intensity of extruded disc material (Figure 2A-b), and presence and extent of T2w hyperintense intramedullary lesions (Figure 2D-d).

The signal intensity of extruded material was classified as homogenous if the material was markedly T2w hyperintense (Figure 2A-a). If T2w iso- to hypo-intense areas were present within the extruded T2w hyperintense material, it was classified as heterogeneous because of a partially solid component consistent with suspected small amounts of calcified disc material within the gelatinous material (Figure 2B-b).

If an intramedullary hyperintense lesion was present on T2w images, measurement of the length was made by sagittal T2w images and dividing by the length of the C3 vertebra to calculate the T2w

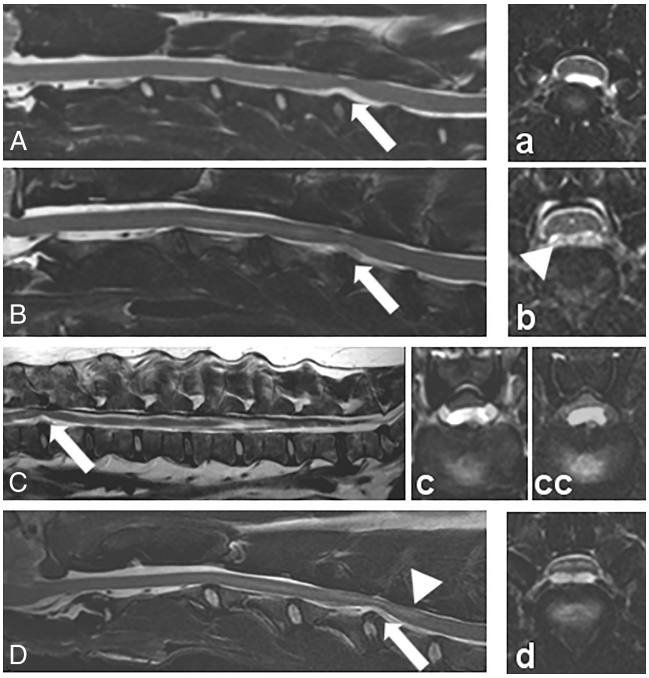

FIGURE 2 Magnetic resonance T2w images of cervical and thoracolumbar hydrated nucleus pulposus extrusion (HNPE) with different HNPE signal intensities and intramedullary changes. A, Sagittal T2w image of the cervical spinal cord of a 6 years old, male fox terrier, HNPE at C5-6 (white arrow) with a homogeneous marked T2w hyperintense appearance. a: Transverse T2w section of the HNPE at C5-6 seen in A. B, Sagittal T2w image of the cervical spinal cord of a 10 years old, female Dachshund, HNPE at C4-5 (white arrow) with a heterogeneous appearance. B: Transverse T2w section of the HNPE at C4-5 seen in B, arrow head points at the area of reduced signal intensity within the extruded material, suspected to be a more solid component of the disc extrusion. C, Sagittal T2w image of the thoracolumbar spinal cord of a 9 years old, female neutered mixed breed dog, HNPE at T13-L1 (white arrow) with a heterogeneous appearance. C and cc: Transverse section of the HNPE at T13-L1 seen in C in T2w (c) and fat suppression sequence STIR (cc). D, Sagittal T2w image of the cervical spinal cord of a 9 years old, male neutered Labrador Retriever, HNPE at C4-5 (white arrow) with intramedullary hyperintense lesion from mid C4 to mid C5 spinal cord segments (arrow head). D, Transverse T2w section of the spinal cord dorsal of C4 with asymmetrical intramedullary T2w hyperintense lesion predominantly in the gray matter (cranial of the HNPE seen in D)

hyperintensity length ratio adopted for cervical myelopathy.[16] In dogs with thoracolumbar HNPE, intramedullary lesions were not detected during MRI examination.

2.4 | Treatment and outcome

Whether the patient received surgical or conservative treatment was dependent on the preference of the owner and attending surgeon and neurologist, but not on the severity of neurological signs. Surgery consisted of a ventral slot at the affected intervertebral disc space in surgically-managed dogs with cervical HNPE or a hemilaminectomy in the surgically-managed dog with thoracolumbar HNPE. Postoperative care included cage rest, physiotherapy, and multimodal analgesic medication, which was composed of metamizole (50 mg/kg IV or PO or rectal q8h), gabapentin (5-10 mg/kg PO q8-12h) or pregabalin (4 mg/kg PO q8-12h) and fentanyl-lidocaine-ketamine continuous rate infusion (fentanyl 0.001-0.002 mg/kg/h, lidocaine 0.3-0.6 mg/kg/h, and ketamine 0.06-0.12 mg/kg/h). Conservative management included cage rest, physiotherapy, and analgesic medication as required, which consisted of metamizole, gabapentin, or pregabalin with or without fentanyl-lidocaine-ketamine continuous rate infusion or methadone (0.2-0.4 mg/kg SC q6h). Betanechol (0.5 mg/kg PO q8h) and phenoxybenzamine (0.5 mg/kg PO q12h) were administered to both groups, if urinary retention was apparent.

Follow-up period included time of hospitalization and reevaluation visits. Short-term outcome and time to regain functional recovery were recorded for all patients. Functional recovery was defined as the time point of reappearing ambulation without by means of any source of weight support, even if weakness was present. Long-term outcome was not considered in our study, because follow-up visits were available only occasionally.

2.5 | Statistical analysis

For statistical analysis, SAS Enterprise Guide 7.1 (SAS Institute, Inc, North Carolina) was used. Testing for Gaussian distribution was performed by the Shapiro-Wilks test as well as visual analysis of q-q plots. Fischer's exact test was used for comparison of independent qualitative samples, and a *t*-test, Wilcoxon test or 2-way analysis of variance was used for quantitative independent samples. Quantitative data were correlated by Pearson's correlation coefficient. Additionally, a nonparametric equivalence test with Hodges-Lehmann estimation was performed for the variable "time to functional recovery" to show that the mean location shift lies within the 95% confidence interval (CI). A significance level of $P \leq .05$ was chosen.

3 | RESULTS

3.1 | Animals

The search identified 1349 examinations of dogs with suspected myelopathy of which 357 were follow-up examinations. Of the 992 dogs with myelopathy, 445 dogs underwent MRI examination. In 415 dogs, myelopathy was caused by diseases other than HNPE. Patient data from 2006 to 2012 identified an additional 6 dogs with HNPE, but precise numbers on dogs with myelopathy in general could not be ascertained because patient data were not entirely available because of a change in the software in 2012 (Figure 1). In summary, 36 dogs with suspected HNPE could be included. Eighteen dogs received surgical intervention and 18 dogs were treated conservatively with cage rest, physiotherapy, and analgesic medication, if required. Of the included dogs, 38.9% were male intact, 27.8% male neutered, 22.2% female intact, and 11.1% female neutered. The male-female ratio was 2 : 1. The general male-female ratio of the hospital population of dogs from 2012 to 2018 was 1.08 : 1. The median age at the time of presentation of surgically-treated dogs was 121.2 months (range, 84-153 months) and of conservatively-treated dogs was 105.2 months (range, 67-158 months; *P* = .479). Median weight was 16.5 kg (range, 5.2-60 kg) with no statistical difference between surgically- and conservatively-treated dogs (*P* = .19). The affected population consisted of 11 mixed breed dogs, 4 Dachshunds, 3 Poodles, 2 Whippets, 2 Jack Russell Terriers, 2 Bernese Mountain dogs, and 1 each of Miniature Schnauzer, Yorkshire Terrier, Miniature Pinscher, Lhasa Apso, Labrador Retriever, Kromfohrlander, Small Munsterlander, Fox Terrier, German Bracke, Dalmatian, Border Collie, and Beagle dog with no statistical difference among treatment groups (*P* = .06).

3.2 | Clinical findings

Of all dogs (both surgically- and conservatively-treated dogs) 1 dog was ambulatory paraparetic (2.8%; surgical n = 1/conservative n = 0), 2 nonambulatory paraparetic (5.6%; surgical n = 0/conservative n = 2), 4 ambulatory tetraparetic (11.1%; surgical n = 2/conservative n = 2), 22 nonambulatory tetraparetic (61.1%; surgical n = 11/conservative n = 11), and 7 dogs were tetraplegic with intact nociception (19.4%; surgical = 4/conservative n = 3). No statistical difference was found between groups (*P* = .072). Signs of spinal hyperesthesia were evident in 10 dogs (27.8%; surgical n = 6/conservative n = 4), not apparent in 24 dogs (66.7%; surgical n = 12/conservative n = 12), and unknown in 2 dogs (5.6%; surgical n = 0/conservative n = 2). Information about defecation and urination was available for 30 dogs: 5 dogs had urinary retention (16.6%; surgical n = 4/conservative n = 1). No dog had urinary or fecal incontinence or fecal retention.

Median elapsed time between onset of clinical signs and presentation to the hospital was 1.9 days (range, 0.1-7 days) in surgically-treated dogs and 0.81 days (range, 0.1-3 days) in conservatively-treated dogs (*P* = .0811).

3.3 | MRI findings

Detailed MRI reports were available for all dogs. The MRI sequences were available for detailed retrospective analysis in 34 cases: MRI identified HNPE at C4-5 in 16 dogs (44.4%; surgical n = 11/conservative n = 5), C3-4 in 8 dogs (22.2%; surgical n = 4/conservative n = 4), C5-6 in 7 dogs (19.4%; surgical n = 2/conservative n = 5), T13-L1 (for MRI see Figure 2C) in 3 dogs (8.3%; surgical n = 1/conservative n = 2), C2-3 in 1 dog (2.8%; surgical n = 0/conservative n = 1), and C6-7 in 1 dog (2.8%; surgical n = 0/conservative n = 1; *P* = .2823). Median maximal cross-sectional spinal cord compression (n = 30) was 24% (range, 0%-58%) in surgically-treated dogs and 17.8% (range, 0%-61.6%) in conservatively-treated dogs (*P* = .3364). Intramedullary intensity changes were present in 7 dogs evaluated (n = 34); (20.6%; surgical n = 4/ conservative n = 3). The median ratio between intramedullary hyperintensity and length of C3 was 0.98 (range, 0.25-1.5) in surgically-treated dogs and 0.37 (range, 0.25-0.6) in conservatively-treated dogs (*P* = .1930). In 33 dogs, evaluation of HNPE signal intensity on MRI could be performed. Twenty-one dogs had a homogenous markedly T2w hyperintense signal of the extruded material (Figure 2A), whereas 12 dogs had heterogeneous appearance in T2w with presence of isointense areas (Figure 2B). Dogs with heterogeneous material were more likely to receive decompressive surgery. Only 33.3% of the dogs with homogenous material underwent surgery, whereas 75% of the dogs with heterogeneous extruded disc material were treated surgically (*P* = .0324).

3.4 | Treatment and outcome

Clinical data for a median follow-up time of 53.9 days (range, 0-759 days) was available for all dogs. The dogs for which no follow-up was available (=0 days) died immediately after surgery. Functional recovery was achieved in 33 dogs (91.7%; surgical n = 16/conservative n = 17); 3 dogs (8.3%) died within 4 days after anesthesia. After decompressive surgery, median time to functional recovery was 6.6 days (range, 0-28 days) and with conservative treatment 5.9 days (range, 0-15 days; Figure 3A; *P* = .37), location shift lies between 95% CI). Of the dogs that were nonambulatory paretic or paraplegic at initial presentation, 71% were ambulatory within 9 days (surgical n = 10/ conservative n = 12; Figure 3B) and 58% were ambulatory within 7 days (surgical n = 7/conservative n = 11). One dog that was ambulatory tetraparetic at the time of presentation deteriorated after surgery and was nonambulatory tetraparetic for 6 days. One nonambulatory tetraparetic dog was treated initially conservatively, but mildly deteriorated 2 days after initial MRI and underwent surgery 3 days after the initial MRI examination and was ambulatory 3 days postsurgery. This dog was included in the surgically-treated group. Only 1 dog (2.8%) took >15 days to functional recovery and dog was treated surgically.

Urination was normal at the time of last follow-up in all surviving dogs, where this information was available (surgical n = 11/conservative n = 16).

Three dogs (8.3%) died within 4 days (Figure 3B): 2 dogs (5.6%) died on the table immediately postsurgery from cardiorespiratory arrest and 1 conservatively-treated dog (2.8%) suffered from cardiorespiratory arrest and was euthanized 4 days after the initial MRI examination. Postmortem MRI was suggestive for ascending-descending myelomalacia: the HNPE was not visible anymore, but there was a marked and diffuse T2w hyperintense lesion and spinal cord swelling from C3 to T1 (Figure 4). Necropsy was declined by the owner. On initial MRI, these 3 dogs had cervical lesions (C5-6, n = 2; C3-4, n = 1) and 2 had intramedullary T2w hyperintense lesions. The median ratio length of the hyperintense lesion to the length of the C3 vertebral body of the dogs that died was 0.7 (range, 0.6-1.5) and of those that survived was 0.065 (range, 0-1.2; *P* = .0011). The ratio of intramedullary lesion likewise had an influence on the time to functional recovery (Figure 3C): dogs showing functional recovery within 9 days had a median intramedullary length ratio of 0.021 (range, 0-0.25) whereas dogs that did not achieve functional recovery within 9 days, including those that died, had a median intramedullary length ratio of 0.39 (range, 0-1.5; *P* = .0035; Figure 3A,B) independent of treatment modality. Weight (*P* = .0900), sex (*P* = .6058), age (*P* = .5832), neurological status at presentation (*P* = .0817), presence of spinal hyperesthesia (*P* = .9770), duration of neurological signs (*P* = .0879), localization of the HNPE (*P* = .2708), severity of spinal cord compression (*P* = .3524), signal intensity of extruded disc material (*P* = .8751), and any combination of 2 of these factors did not have an effect on time to functional recovery or whether or not the dog died.

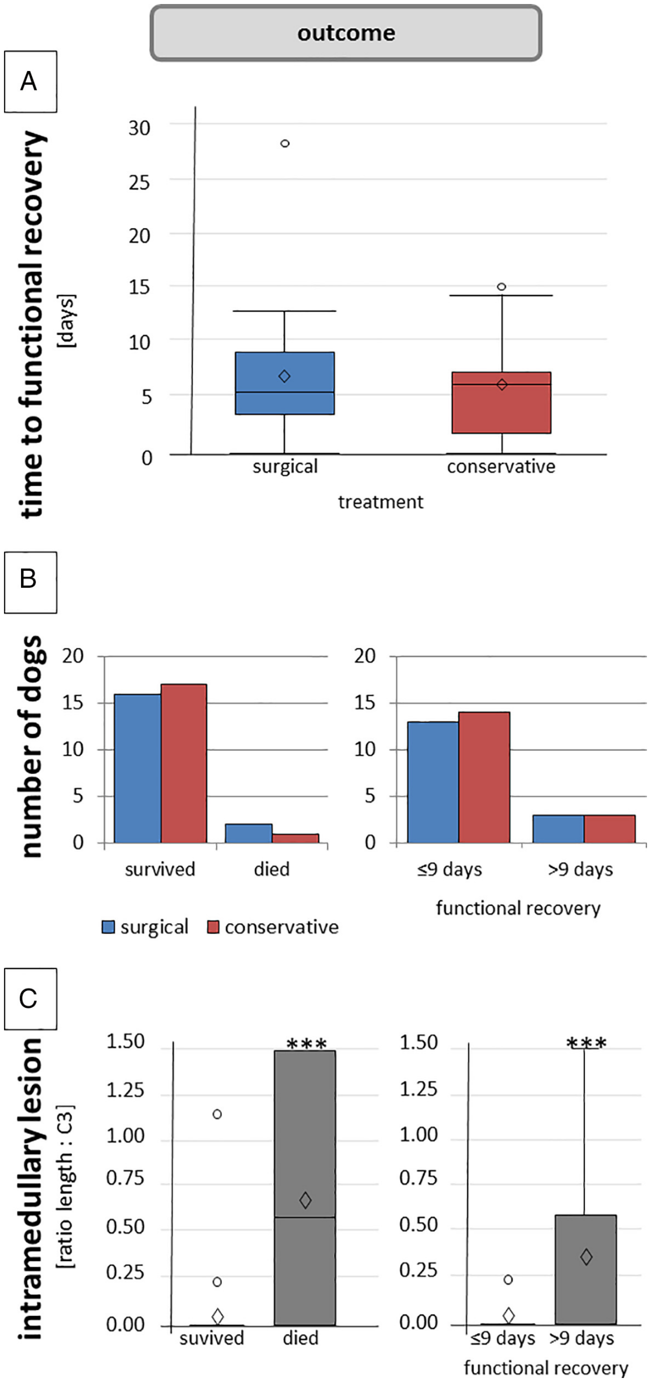

FIGURE 3 Clinical outcome in hydrated nucleus pulposos extrusion. A, Surgical treatment did not have an influence on time to functional recovery (P = .37). B, Surgical treatment did not influence recovery time and unfavorable outcome. C, Length of intramedullary lesion had a significant influence on time to functional recovery (P = .0011) and short-term survival (P = .0035). Tukey boxplots show upper and lower quartile, diamond represents mean, horizontal line presents median, circle show outliners

4 | DISCUSSION

Until 2017, no clear recommendation on treatment of HNPE could be made,[9,10] because comparative studies evaluating surgical and conservative management have been lacking. A recent study[15] was the first that clearly opposed the predominant reports favoring surgical treatment in HNPE.[4,7] The study stated, that there was no significant difference in outcome between surgical and conservative management of HNPE. Moreover, our study clearly supports the hypothesis that surgical intervention is not superior to conservative treatment because time to functional recovery did not differ between dogs that underwent decompressive surgery and those that received conservative treatment.

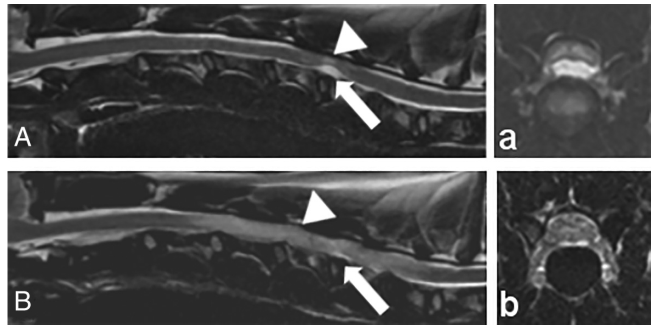

FIGURE 4 Magnetic resonance images of 1 dog dying caused by suspected ascending-descending myelomalacia 4 days after diagnosis of hydrated nucleus pulposos extrusion (HNPE) C5-6.
A, a: Sagittal (A) and transverse (a) T2w sequences at initial presentation, HNPE at C5-6 (arrow) with intramedullary hyperintense lesion (arrow head). B, b: Post mortem images, sagittal (B) and transverse (b) T2w sequences after the patient was euthanized in agony 4 days after initial presentation, HNPE at C5-6 is not visible anymore (arrow) but there is a marked intramedullary hyperintense lesion with spinal cord swelling from C3 to T1 (arrow head)

Former recommendations for decompressive surgery for HNPE[4,7] generally were based on data evaluated for treatment of cervical IVDH Hansen type I.[17] In the latter, decompressive surgery is recommended if moderate to marked neurological deficits are present.[1,18] Fifty-six percent of dogs that are not ambulatory achieve functional recovery within 1 week after decompression by ventral slot.[1] Conversely, data on conservative treatment of nonambulatory dogs suffering cervical IVDH type I are rare. In 1 study,[19] outcome of 3 dogs with marked neurological deficits caused by suspected cervical IVDH type I and unsuccessful conservative treatment was reported. In general, outcome after conservative treatment of nonambulatory dogs with cervical IVDH type I is thought to be much less favorable than in dogs with thoracolumbar IVDH.[18] Data on HNPE so far show similar or slightly superior results: 28.6%-100% of dogs regained functional recovery after decompressive surgery within 7 days[3,13–15] whereas the reports of HNPE treated conservatively suggest a similar favorable prognosis with 80%-100% of the reported cases regaining functional recovery within 7 days.[3,11–13,15]

Despite the retrospective nature our study, the 2 groups did not differ significantly regarding breed, age, and sex, severity of clinical signs, or spinal cord compression. Median time to functional recovery was 6.6 days after decompressive surgery, and 5.9 days with conservative treatment. Fifty-eight percent of all dogs were ambulatory after 7 days, 71% within 9 days. All but 4 dogs achieved functional recovery in ≤15 days. One of these 4 dogs took 28 days to achieve functional recovery, 2 died in the immediate postoperative period and 1 dog died of cardio-respiratory arrest caused by ascending-descending myelomalacia 4 days after initial diagnosis. Weight, sex, age, neurological status at presentation, presence of spinal hyperesthesia, duration of neurological state, localization of the HNPE, extent of spinal cord compression, signal intensity of extruded disc material, and treatment or any combination of these 2 factors did not influence outcome. Only the ratio between intramedullary hyperintensity and length of C3 correlated with the time to functional recovery and with short-term survival.

The different pathophysiology of HNPE and IVDH Hansen type I might be a potential explanation. In HNPE, the consistency of the extruded disc material is gelatinous to liquid[7] whereas it is calcified and firm in IVDH Hansen type I.[8] Therefore, in HNPE it is possible that the extruded material is spontaneously dispersed in a relatively short-time period within the vertebral canal, subsequently resolving the compression of the spinal cord. This hypothesis is supported by previous reports[11,13] in which MR images showed a compression of the spinal cord because of HNPE on initial presentation. In 1 case, 2 months after functional recovery, a MRI examination showed complete dissolution of the compression. One of the cases in our study had comparable results: The MR images at the day of presentation showed compressive HNPE that was no longer visible 4 days later when a postmortem MRI was performed.

Furthermore, our data suggest that an extended intramedullary lesion is associated with a recovery time of >9 days or with development of ascending-descending myelomalacia or perioperative death. It is known from thoracolumbar IVDH that the length ratio of the visible intramedullary lesion on MRI affects prognosis.[16] The intramedullary hyperintense signal is thought to represent malacia, necrosis, and edema of the spinal cord in acute spinal cord injury,[20] which reflects substantial damage of neural tissue. In contrast, the absence of a visible intramedullary change could indicate the presence of a concussion, which is defined as reversible traumatic paralysis of nervous system function.[21]

In our study, the MRI appearance of the extruded material seemed to influence the decision of the surgeon: HNPE with a heterogeneous appearance were more likely to be treated surgically. Heterogeneous MRI appearance could indicate the presence of at least partly firm and less liquid disc material causing long-term compression without surgery. Such material could have persuaded the surgeon or neurologist to select decompressive surgery, leading to a certain bias in our study.

Most reports (except 4[5,6,10,12]) solely show cervical HNPE. In our study, we also found that HNPE may occur in the thoracolumbar region: 3 dogs had HNPE at the level of T13-L1. Although no histopathological examination was performed to prove that the compressive material seen on MRI was degenerated disc material, it had the same appearance on MRI as cervical HNPE: midventral extradural spinal cord compression because of material with the characteristic "seagull"-like shape[3] and hyperintense appearance in comparison to spinal cord parenchyma in T2w and fat suppression short tau inversion recovery sequences (STIR; Figure 2C-cc). Another study[22] found significant less mineralization of extruded disc material in the cervical than in the thoracolumbar spinal column. The authors proposed that variances in biomechanical, biochemical, and metabolic aspects of the intervertebral discs at different locations were responsible for different amounts of degeneration in the cervical and thoracolumbar intervertebral discs.[22] These findings are consistent with the local occurrence of HNPE more frequently reported in the cervical region and consisting of less calcified disc material.

As ours was a retrospective, single center study, sometimes limited availability of clinical information and re-evaluation of all MRI sequences as well as small case numbers limit the power of our study. The results however are in accordance with previous studies and reports,[3,11–13] which makes our study a valuable endorsement for conservative treatment in HNPE.

In conclusion, conservative treatment of cervical and thoracolumbar HNPE in dogs can be recommended because superiority of surgical intervention could not be shown. Prognosis for rapid functional recovery is good if no intramedullary lesion is visible on MRI. Because conservative treatment spares the risk of iatrogenic damage to the spinal cord as well as the risk of perioperative hemorrhage and postoperative wound complications, conservative treatment might, therefore, be considered advantageous for the patient.

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CONFLICT OF INTEREST DECLARATION

Andrea Tipold serves as Associate Editor for the *Journal of Veterinary Internal Medicine.* She was not involved in review of this manuscript.

OFF-LABEL ANTIMICROBIAL DECLARATION

Authors declare no off-label use of antimicrobials.

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

All examination were carried out with the full consent of the patients'-owners according to the ethical guidelines of the University of Veterinary Medicine Hannover, Foundation.

ORCID

Jasmin Nessler https://orcid.org/0000-0002-1427-2555

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