Our Approach to Intervertebral Disc Disease in Dogs: A Review of the Current Literature

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Abstract

Intervertebral disc disease is a common disorder affecting the spinal cord of canine patients. The clinical appearance of intervertebral disc disease can vary significantly and outcome as well as prognosis may be strongly dependent on the location, the severity and the duration of the disease. Over the past 60 years a lot of research had been done on this topic in order to achieve a better understanding and also to improve the treatment options and outcome of intervertebral disc diseases in dogs. This review summarizes the clinical appearance, the classification system, diagnostic possibilities, surgical intervention and prognosis and gives a broad overview over the current literature on intervertebral disc diseases in our canine patients.

Keywords

Intervertebral disc disease; Dogs; chondrodystrophic; Hansen type

Introduction

In the 1950ies ground setting work was published regarding intervertebral disc disease (IVDD) in dogs. Olsson and Hansen, both working at the University of Stockholm, presented their results of extensive clinical and histological investigations in mainly chondrodystrophic patients with IVDD [1,2]. This data was later widened by the work of Funkquist introducing surgical decompression of intervertebral disk extrusions (IVDE) using a laminectomy, and comparing these surgical results with conservative treatment of dogs affected by an IVDE [3,4]. Since then, numerous publications have provided more clinical knowledge and led to modifications of decompression techniques; but still little has been changed in the clinical approach of IVDE. Recently, however, new research using advanced imaging techniques has given more detailed descriptions of the different variations of the disease. This has further improved the prognostic accuracy of treatment and outcome. Therefore, it is the objective of this review to summarize current published data and evidence for the classification, prognosis and treatment of IVDE in dogs.

Classification of IVDD and IVDE in Dogs

The main work of Hansen is based on the histology of degenerated intervertebral discs in chondrodystrophic dogs and is still valid and in use [5]. According to Hansen, complete ruptures of the annulus fibrosus (AF) with extrusion of nucleus pulposus (NP) are classified as Hansen type 1 (IVDE); while partial ruptures of the AF with some degree of AF protrusion are classified as Hansen type 2 (IVDD) [1].

IVDE Hansen Type 1

Funkquist introduced 1962 a sub-classification of the Hansen type 1 based on the length of dispersion of the extruded NP. She proposed three subtypes, subtype 1 and 2 with only a short dispersion of extruded NP within the spinal canal and subtype 3 with a longer dispersion over three or more vertebrae. Recently, in a study using MRI scans, subtype 1 and 2 have been described as nondispersed and dispersed IVDE respectively [6]. Further, patients with a herniation classified as subtype 3 have shown a poorer outcome when treated conservatively, in comparison to subtype 1 and 2 [3]. A very similar form of the Funkquist IVDE type 1 subtype 3, with long dispersion of NP, has been described clinically and myelographically by Tartarelli and co-workers [7]. Myelography in these patients showed significant compression of the spinal cord over several vertebrae, making extensive hemilaminectomies necessary to relieve the compressed nervous tissue. Tartarelli and co-workers intraoperatively found considerable hemorrhage within the epidural space. Therefore, the term disk extrusion with extensive hemorrhage (DEEH) was proposed for the Funkquist IVDE type 1 subtype 3 [7]. To identify the extrusion of NP and bleeding in DEEH, computed tomography (CT) has been described to be a reliable diagnostic technique (Figure 1) [8]. According to some studies, a smaller percentage of patients with DEEH recover in comparison to patients with the classical Hansen type 1 IVDE (subtype 1 and 2) [3,9]. The necessity of extensive decompression in many cases of DEEH and the severity of the clinical signs makes it reasonable to categorize the DEEH as a different clinical entity of the Hansen IVDE type I (Table 1). Another form of Hansen type 1 IVDE described in the literature is the acute IVDE of non-degenerated NP. This has been observed in both dogs and cats. In the event of trauma, the AF of the disc can acutely rupture and viscous non-degenerated NP extrudes under significant pressure, leading to intramedullary contusion damage, often with severe clinical signs. Two subtypes have recently been described; the acute non-compressive nucleus pulposus extrusion (ANNPPE) and the intradural/intramedullary IVDE (IIIVDE) [10]. In most cases of ANNPPE, no residual NP is identified during imaging, making a surgical decompression ineffective [11]. But in an event of IIIVDE sometimes intradural nucleus material can be found, making a surgical intervention necessary. Dogs and cats with an acute IVDE should therefore be assessed with an MRI to detect any intramedullary changes (Figure 2). Should there be a loss of deep pain perception (DPP) and a hyperintense intramedullary signal found in a T2-weighted sequence of the MRI, the prognosis is guarded [6,12,13]. This form of traumatic IVDE has in the literature also been called high velocity-low volume IVDE, and sometimes Hansen type 3 [11,14,15].

Another documented variation of canine IVDE, regarding the degenerative state of the extruded NP and the clinical features and treatment, is the hydrated NP extrusion (HNPE). More than 50 cases have been published of this type of herniation [16-21]. All cases, with one exception, were diagnosed in the cervical area and clinically most of them have a peracute/acute onset presented with severe signs...
Remarkably no pain, or only mild pain, was observed and reported [16-18,20]. MRI has been shown to be the diagnostic imaging technique of choice in these cases, since the extruded NP is not mineralized and can therefore be difficult to assess with computer tomography (CT). The extruded NP mass is visible in MRI scans mostly ventral to the spinal cord with the same signal intensity as the NP (hyperintense in T2-weighted images), resulting in a mild to moderate ventral cord compression (Figure 3). The fast onset of signs in these patients suggests a pressurized extrusion with strong contusion of the spinal cord, often resulting in a hyperintense intramedullary signal in the T2-weighted sequence (Figure 3). Outcome of the reported cases has been shown favorable with both surgery and conservative treatment [16-21]. Extruded NP material from these patients showed viscous properties, and histologically mildly degenerative signs [21]. When conservatively treated cases were rescanned after four weeks, the extruded NP material was absorbed which may explain the fast recovery shown in patients with a HNPE [19,20]. In 2013 Fadda described a Hansen IVDE type I to the lateral side of the IVD compromising the nerve root and the nerve passing through the foramen (Figure 4). This form of IVDE was in
the publication named a far lateral disc extrusion [22]. Patients with a far lateral disc extrusion are presented with radicular pain, and surgical removal of the extruded NP may lead to a quick recovery to full function. Fluoroscopically guided perineural injections of methylprednisolone ± bupivacaine has recently been successfully used to treat the radicular pain caused by lateralized cervical disc extrusions [23]. A rare entity of NP extrusion has been described under the name of Schmorl’s node. This is described as a herniation of NP into the body of the vertebra through the endplate, leading to an inflammation with subsequent bone absorption (Figure 5) [24-27]. Most of these cystic lesions are incidental findings on CT or MRI scans. But clinical presentation can be caused by pain in the affected IVD and vertebra [25]. The limited information from the literature and from anecdotal cases of this rare extrusion does not allow today for an evidence based conclusion on the best treatment protocol.

**Summary of the Hansen type 1 classification:** In summary, the basic Hansen classification that distinguishes between NP extrusions (Hansen type 1) and AF protrusions (Hansen type 2), is still useful. However, data collected in recent years show that there are distinct subtypes of the Hansen type 1 IVDE. These subtypes have different clinical presentation, and subsequently may benefit from different diagnostic techniques and therapy. Differences seen in the clinical picture of the Hansen type 1 subtypes are based on the degenerative state of the NP, but also on the velocity and localization of the extrusion. Clinical features of the six subtypes described in this review are summarized in table form as subtypes Hansen type 1a-f (Table 1).

**IVDD Hansen Type 2**

Hansen type 2 IVDD and protrusion is described as a fibroid degeneration and an age-related process that occurs in all breeds, but is documented mainly in nonchondrodystrophic dogs older than 7 years [1,28]. Hansen type 2 IVDD is characterized by a fibrous collagenization of the NP with concurrent degeneration of the AF, leading to partial ruptures and dorsal bulging of the AF ending in...
chronic mild-severe cord compression [1,28]. Signs are in most cases progressive, ranging from pain and ataxia to paresis and incontinence. Today, surgical decompression via corpectomy or ventral slot is recommended to relieve symptoms manifested in these patients [19-31]. Prognosis depends on (1) the degree of spinal cord damage, with mainly axonal atrophy and gliosis, often visible in T2-weighted MRI scans as a hyperintense signal, and (2) possible reperfusion injury following decompression. Rate of successful outcome has been shown to be lower for a chronic Hansen type 2 protrusion compared to a type la IVDE [32]. Type 2 IVDD sometimes occurs with biomechanical stress and/or instability, leading to degenerative changes of the spine including Hansen type 2 protrusion, spondylosis, ligament hypertrophy and facet joint changes such as intraspinal synovial cysts. Prevalence of these types of degenerative changes is higher in disc-associated cervical spondylomyelopathy (CSM) (Figure 6), and the degenerative lumbar-sacral syndrome (DLSS) [33-35]. Decompression of the spinal cord/nerve roots in these patients often needs not only removal of the protruding disc, but also release from the hypertrophied dorsal ligament and bone proliferations. Existing instability can be addressed by traction-fusion of the affected segment [33,36]. Additionally, in human spine surgery, a form of lumbar disk protrusion including a gas-containing cyst has been described [37,38]. Gas in the epidural space has been shown to be related to a disc vacuum phenomenon, and a one-way valve mechanism is suggested to be located between the gas in the disc and the epidural space. Clinically, human patients can suffer from lumbosacral radicular pain, often not responding to conservative treatment with rest and anti-inflammatory medication [37,38]. A similar form of gas-containing disc protrusion has recently been described in dogs with DLSS (Figure 7). The clinical significance of these epidural gas accumulations is unknown, but surgically treated DLSS patients with epidural gas accumulations have shown a good outcome retrieving their normal activity level postsurgery [39]. Hansen noted 1952 that in some cases it is not possible to histologically classify between type 1 and 2. It is logical to assume, that a type 2 partial AF rupture can protrude for some time and then rupture completely leading to an additional type 1 IVDE (‘one on two’) (Figure 8). There is a lack of evidence in the literature regarding prognosis of these specific cases, but surgical intervention is warranted if compression with neurologic deficits are present.

![Figure 5: Schmorl's node of the L7 in an Airedale Terrier (A) and a Rottweiler (B) presented with lumbosacral hyperesthesia.](image)

![Figure 6: Hansen type 2 IVDD in a patient diagnosed with disc-associated cervical spondylomyelopathy (white arrows).](image)
Prognosis of Patients with an IVDE

Most of the cases described in the literature are chondrodystrophic patients. These dogs often suffer from an IVDE with degenerated nucleus pulposus (Hansen type 1 a+b, Table 1). Prognosis of patients with an IVDE may be influenced by many factors such as severity of clinical signs, rate of onset, ambulation and deep pain perception (DPP).

Older and newer studies agree, that successful surgical outcome can be seen in 86-96% of non-ambulatory chondrodystrophic patients with intact DPP (Frankel score 3-1), finally regaining ambulation and bladder control [40-47]. However the success rate in larger breed dogs seems to be slightly lower than in chondrodystrophic dogs, with 78-85% [32,48]. A positive indicator for fast recovery of all IVDE patients is some motoric tonus or function shown after surgery [47]. Predicted recovery time and needed hospitalization is an important pre-operative information for the owner. Reported time until ambulation is around 7-14 days in chondrodystrophic patients [40,47]. In cases with more severe signs (Frankel score 1) it may take longer to recover [44,45]. Time needed to establish bladder control after hemilaminectomy is typically shorter than time needed for regaining ambulation, and has a correlation to severity of preoperative signs [44]. Evidence regarding healing time and final prognosis, in patients specifically affected by a Hansen type 1 IVDE with intact DPP (Frankel score 4-2, Table 2), shows some discrepancy when only based on anamnesis and clinical status. Most studies found a correlation between the severity of clinical signs and time to ambulation. Rate of onset of the symptoms seem to have only some effect on recovery time, but not all studies confirm this correlation [9,40-44]. Other studies investigating amount of compression through a non-dispersed IVDE type 1 visible on preoperative images, have shown no correlation to the outcome of surgical treatment [6,9,42,44]. And, no correlation was found between outcome and location of the IVDE [45].

Furthermore, disc extrusions with extensive hemorrhage (DEEH) seem to have a lower healing rate after decompression surgery. Buttin and colleges suggests that the lower healing rate may be due to the strong contusion of the spinal cord generated by the acute IVDE, but also due to the often-necessary extended surgery [9]. In contrast, Tartarelli and colleges did not confirm these findings with all DEEH patients with remaining DPP recovering to ambulation [7]. Cases

Figure 7: CT scan of a French bulldog showing a disc protrusion with an epidural gas accumulation (black arrows) at the L7-S1 level.

Figure 8: Intraoperative views of a Hansen type 1 extrusion (arrow) on top of a Hansen type 2 protrusion at the L7-S1 level. The tear in the protruding annulus fibrosus (arrow head) can be seen after removal of the extruded nucleus pulposus material (#).
with a hydrated NP extrusion (HNPE) show a fast recovery, taking in consideration the severity of the clinical signs. Both surgery and conservative treatment have for these cases shown to be successful [16-20].

Loss of DPP is controversial as a clear prognostic factor, as the testing is subjective and has been performed differently in studies. It is however considered as the only clinical sign, which negatively affects the prognosis of a Hansen IVDE type 1 consistently in all reported studies. The success rate in these patients after surgery is reported 0-76%, with an average around 50% [28,49]. Most of the studies show a higher success rate if the patient is operated within 24 hours after loss of DPP, however one study, does not confirm this time limit [41,50-53]. Loss of DPP as a prognostic factor is however problematic. For instance, the exact time point DPP is lost is often not clearly determined, therefore a ‘cut-off point’ cannot be established clinically. This puts the owner in a rather demanding situation. The owner’s decision to perform expensive surgery with an expected recovery time of four weeks or more is based on a ‘fifty-fifty’ prognosis, and the minimal waiting time after surgery is two weeks before the clinical prognosis can be more precise [12,54]. Recent publications however, using MRI scans to distinguish the prognosis in dogs with loss of DPP and an IVDE, found a strong correlation between surgery outcome and presence, or absence, of a hyperintense intramedullary signal in T2-weighted scans [6,13]. Length of the hyperintense signal subdivided prognosis even further. Dogs having loss of DPP (Frankel score 1 and 0) and no T2 signal recovered in 100% of the cases. Dogs having loss of DPP (Frankel score 1 and 0) and a short T2 signal recovered in 55% of the cases. Dogs having loss of DPP (Frankel score 1) and a T2 signal longer than three times the L2-vertebra recovered in 31% of the cases; and only in 10% of the cases with Frankel score 0 and a T2 signal longer than three times the L2-vertebra [13]. This suggests that using an MRI scan to evaluate dogs showing a Frankel score 1 or 0 may be recommended to provide a more exact prognosis helping the owner in this emotional situation.

A promising field of research is the investigation of biomarkers detected in the serum or cerebrospinal fluid (CSF). These potential biomarker molecules originate from nervous tissue, and could be used in the future to assess the severity of the damage to the spinal cord, as the use of liver enzymes assessing liver damage today [55-57].

Treatment of spinal cord injury (SCI) and IVDD is of large interest in human medicine. Unfortunately, there is today no established drug or cell treatment for acute or chronic SCI or IVDD in humans. The dog affected by an IVDD/IVDE can positively be used as a translational clinical animal model in search for new effective substances and procedures [58-63].

### Table 2: The modified Frankel score.

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
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<tbody>
<tr>
<td>5</td>
<td>Normal gait with spinal hyperesthesia</td>
</tr>
<tr>
<td>4</td>
<td>Ambulatory paresis</td>
</tr>
<tr>
<td>3</td>
<td>Non-ambulatory paresis</td>
</tr>
<tr>
<td>2</td>
<td>Paralysis with intact pain perception</td>
</tr>
<tr>
<td>1</td>
<td>Paralysis with absent superficial pain perception</td>
</tr>
<tr>
<td>0</td>
<td>Paralysis with absent deep pain perception</td>
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Surgical Treatment of IVDE

Most publications describing success of conservative treatment of IVDE are older, except for the publications of Levine et al. and Mann et al. [3,4,64-70]. One essential drawback of these studies is the lack of diagnostic proof that the dogs were actually suffering from an IVDE. The dogs had assumed IVDE, and no classification was possible. Several differential diagnoses exist such as fibrocartilaginous embolism, discospondylitis, neuritis, intraspinal cysts and tumors. Furthermore, patient care was different within the studies but also compared to conservative treatment today regarding medication and rehabilitation. Another factor making the comparison of these studies difficult, is the severity of clinical signs, reported 76,4% (50-100%) of the conservatively treated patients being ambulatory compared to 91,8% (66-100%) being non-ambulatory in the surgically treated cases [3,4,49,64-67,69-81]. Therefore it may be problematic to compare these conservative treatments with other publications reporting success rate of surgically treated dogs with IVDE. To our knowledge no controlled prospective trials have been published. In controlled studies, diagnostic imaging of all patients would be necessary to confirm the IVDE and to classify the type of IVDE. Since subtypes of IVDE have different prognoses and treatment options, it can be argued that they should also be differentiated in studies. Unfortunately, ethical concerns are high regarding a randomized prospective comparison between surgical decompression and conservative treatment, due to the reported high success rate of decompressive surgery [82]. Despite the lack of scientific evidence in publications regarding conservative treatment, success rates reported are quite uniform in all studies. It has been reported that 82-100% of ambulatory dogs (Frankel score 5 and 4) were treated successfully conservatively, but only 23-55% of non-ambulatory dogs [3,4,66,67,69,83]. In cases with a Frankel score 3 reported relapse rate during conservative treatment was 30-50%, thus lowering number of patients with a final successful outcome [5,12,66,67,70]. For cases with a Frankel score 2-1 reported success rate of surgery is clearly superior to conservative treatment, and success of conservative treatment in cases with Frankel score 0 is close to zero [3,5,28,66,69].

Today we find a wide consent that surgical treatment of IVDE is recommended for spinal pain or paresis unresponsive to conservative treatment, but also for patients with recurrence of clinical signs during or after conservative treatment. Non-ambulatory patients are generally candidates for immediate imaging and decompressive surgery, with the aim of removing all extruded NP material [5,28].

### Further evidence supporting surgical treatment

Newer studies confirm the cascade of events in the epidural space and within the cord that occur after an IVDE. Vascular compromise leads to tissue damage and focal myelomalacia in the cord, and persistent compression affects the lateral columns. Extruded NP induces an epidural inflammation leading to painful radiculitis [84-88]. Not only final treatment outcome, but also length of recovery and morbidity play a key role when choosing between surgical and conservative treatment. High rate of relapse during conservative treatment, leading to prolonged pain, may be considered as an argument for choosing surgical therapy instead of conservative treatment. During conservative treatment, the dog may compensate the loss of axonal function caused by the compression, but unfortunately this cannot be seen in all cases. Recovery with the ability to walk a few steps and urinate without help after surgery can be expected within 7-14 days in up to 96% of the cases [40,41,43-47]. The sooner the dog can move the affected legs and empty the bladder, the lower is the complication rate and loss of musculature. Relief of pain inflicted by epidural inflammation induced by NP material is fast after surgery when combined with modern analgesia. These factors seem to be valuable arguments for fast surgical decompression of nervous tissue in non-ambulatory patients.
Less invasive surgical techniques are under development, making hemilaminectomy procedure less traumatic and painful [89,90]. In summary, evidence shows that ambulatory dogs with an IVDE can be treated conservatively, however, keeping in mind the considerable risk of relapse or incomplete remission with chronic pain making surgery necessary. Additionally, robust evidence shows that surgery is recommended in patients with a Frankel score 2,1 or 0. For cases with a Frankel score 3, however, evidence to do surgery is weaker due to lack of controlled studies. Importantly, high rate of reported relapse and epidural inflammation in Frankel score 3 cases are additional valid arguments for an immediate decompressive surgery also in these cases.

Recurrence rate of IVDE after surgical treatment

During the first days, up to four weeks after decompressive surgery, reherniation can occur at the same site as the original herniation. To assess this, immediate diagnostic imaging is recommended if unexpected pain or deterioration of neurologic status is detected in the postoperative period. Most cases can fortunately be reoperated with a successful outcome [91-94]. To prevent this complication, fenestration of the extruded IVD was recommended by some authors [46,95,96]. In two case series of 93 hemilaminectomies without and 252 with fenestration recurrence rate was 5%, all recurrent IVDE occurred at a new site [46,49]. In another large study involving 467 hemilaminectomies without fenestration, recurrence rate was reported 6.4%; 83% of reoperations were also here at a different site [91]. Another study using hemilaminectomy without fenestration, show a higher recurrence rate of 14.6% (41 cases out of 281), all cases with herniation of a different IVD [41]. Furthermore Aikawa and colleagues reported 662 operated cases using routine fenestration T11-L1 with a recurrence rate of 2.3% with a 2nd surgery. Additionally, 10% of these operated dogs were treated conservatively for signs of IVDE without radiological conformation. In this study, all recurrent IVDE were also at a different site, and significantly more common in non-fenestrated IVD [97].

Conclusion

Despite that intervertebral disc disease historically has been categorized into two main subtypes, Hansen type 1 and 2, it is significant to recognize and appreciate that we today further can subdivide IVDD and IVDE. These subtypes have different clinical presentation, and subsequently may benefit from different diagnostic techniques and therapy. Differences seen in the clinical picture of the Hansen type I subtypes are based on the degenerative state of the NP, but also on the velocity and localization of the extrusion.

Most of the cases described in the literature are chondrodystrophic patients. These dogs often suffer from a IVDE with degenerated nucleus pulposus. Today we find a wide consent supported by the evidence that surgical treatment of IVDE is recommended for non-ambulatory patients. Successful surgical outcome can be seen in 86-96% of these patients with intact DPP, finally regaining ambulation and bladder control. Less severe cases can be treated conservative keeping in mind the considerable risk of relapse or incomplete remission with chronic pain making surgery necessary. The pathologic events within the spinal canal and cord further advocate a surgical removal of extruded degenerated nucleus pulposus material.

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