Outcome and prognostic factors in non-ambulatory Hansen Type I intervertebral disc extrusions: 308 cases

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Summary
Thoracolumbar intervertebral disc disease is the most common cause of caudal paraparesis in dogs (1). Whilst the pathogenesis of the extrusion has been widely studied, treatment protocols and prognostic factors relating to outcome remain controversial. Recent studies have examined a multitude of factors relating to time to regain ambulation after decompressive surgery. Most intervertebral disc herniations occur in the thoracolumbar region, causing upper motor neuron signs in the rear limbs, which are thought to have a more favourable prognosis compared to the lower motor neuron signs created by herniation of an intervertebral disc in the caudal lumbar region. Due to the potential disruption of the lumbar intumescence, lower motor neuron signs have been reported as having a less favourable prognosis. The purpose of this study was to evaluate the intervertebral disc space as a prognostic factor relating to ambulatory outcome and time to ambulation after decompressive surgery. Hansen Type I intervertebral disc extrusions were studied in 308 non-ambulatory dogs. Preoperative and postoperative neurological status, corticosteroid use, signalment, intervertebral disc space, postoperative physical rehabilitation, previous hemilaminectomy surgery, disc fenestration, return to ambulation, and time to ambulation were reviewed.

Keywords
Intervertebral disc herniation, time to ambulation, dogs

Introduction
Thoracolumbar intervertebral disc disease is one of the most common surgical neurological diseases in dogs. Hansen Type I disc extrusions most commonly occur in chondrodystrophic breeds, but have been reported in large, non-chondrodystrophic breeds (2, 3). Dogs with thoracolumbar intervertebral disc disease may have clinical signs ranging from back pain to paralysis with loss of deep pain sensation.

Treatment protocols vary widely from the use of acupuncture, corticosteroids, decompressive surgical techniques, cage rest, or a combination of the aforementioned. Laminectomy and removal of disc material from the spinal canal has been established as a treatment for non-ambulatory dogs.

Many reports have been published regarding the presence or absence of deep pain sensation as a prognostic factor relative to return to function (2, 4–6). Other prognostic factors studied include degree, duration, and rate of onset of neurological dysfunction, the number of myelographic injections, time to surgical decompression, duration of anaesthesia/surgery, and the use of corticosteroids (1, 4, 7). Age and weight have been reported to have an association with the time required to regain the ability to ambulate (8).

Recent reports have been published examining the time to ambulation after decompressive surgery in non-ambulatory dogs. One study reported that the average length of time to ambulation was 12.9 days and the most important prognostic factor for ambulation was the presence of postoperative voluntary motor function (1). Another study reported a mean of 10.8 days to regain the ability to ambulate in paraplegic patients (7).

The location of the intervertebral disc herniation may also have a prognostic implication when examining upper motor neuron (UMN) vs. lower motor neuron (LMN) clinical signs in the rear limbs. Published reports indicate that patients with LMN lesions have a poorer overall prognosis (9–11). The purpose of this study was to evaluate whether the location of the affected intervertebral disc space has an effect on returning to ambulation or the time required to return to ambulation.

Materials and methods
The medical records of dogs admitted to two private referral specialist practices between June 2001 and June 2004 with the diagnosis of thoracolumbar intervertebral disc disease (IVDD) were reviewed. The dogs included in the study were assessed as having a non-ambulatory paraparesis with or without deep pain perception. All dogs included in the study had a laminectomy performed. Those with congenital malformations, traumatic, infectious, or neoplastic lesions were excluded from the study population.

The data collected from the medical records included signalment, preoperative and postoperative neurological status, preoperative and postoperative corticosteroid use, affected intervertebral disc space, the side...
of decompressive surgery, time to ambulation, physical rehabilitation treatment postoperatively, previous hemilaminectomy for intervertebral disc extrusion, and disc fenestration. The breeds were categorized as Bassett Hound, Beagle, Dachshund, Pekinese, Shih Tzu, and other. The other category contained all dogs of mixed breeds and breeds with insufficient numbers to permit analysis, as a stand alone category. The gender was classified as female, female spayed, male, and male neutered. Age was reported in years and the weight was reported in kilograms. Intervertebral disc spaces between T10–11 and L5–6 were included in this study. Plain radiography and lumbar myelography were performed under general anaesthesia in all cases. Iohexol 240 mg iodine/ml (Omnipaque: Amersham Health) at 0.22 ml/kg was injected into the ventral subarachnoid space in the caudal lumbar region. Lateral and ventrodorsal projections were taken immediately after injection. All of the myelograms were performed by either a Board-Certified Radiologist or the attending surgeon. The side of the hemilaminectomy was recorded. If the patient underwent a bilateral hemilaminectomy, the side in which the predominant amount of disc material was identified was noted. A distinction between UMN and LMN disease was based on the location of the disc lesion. For this study, LMN involvement was considered to be present for dogs with IVDD at or caudal to L3–4. This anatomic classification was based on a previous report (9), and is consistent with spinal cord segments subserving the pelvic limbs. Time to ambulation was obtained from the medical records and the time to ambulation was defined as the number of weeks after surgery until the dog was able to stand and take a series of steps without assistance. A grading system was assigned for preoperative and postoperative ambulatory status

- 0= non-ambulatory;
- 1= weakly ambulatory; and
- 2= strongly ambulatory.

Due to the inclusion criterion of non-ambulatory status, all of the dogs were assigned a preoperative grade of '0'. The cases were divided into categories for postoperative ambulatory status as either non-ambulatory, weakly, or strongly ambulatory. The dogs considered weakly ambulatory were defined as having moderate to severe pelvic limb ataxia with moderate to severe conscious proprioceptive deficits. Those considered strongly ambulatory were defined as having mild pelvic limb ataxia and minimal conscious proprioceptive deficits. Ambulatory patients were placed into groups based on the time to ambulation noted at follow-up examination. The groups were allocated to two, four, eight, and 12 week follow-up examination periods. For this study, those patients that did not regain the ability to ambulate after 12 weeks were determined to be non-ambulatory.

Deep pain perception was evaluated by applying hard pressure by forceps or fingers to the rear digits and looking for a response (i.e. vocalization, head turning, or pupil dilatation).

Preoperative corticosteroid use was determined, if the referring veterinarian or the surgeon administered or prescribed corticosteroids prior to surgical decompression. Postoperative steroid use was determined, if the surgeon administered or prescribed corticosteroids after surgical decompression.

The history of previous surgical decompression for intervertebral disc extrusion and affected disc space were recorded. If disc fenestration had been performed, the site or sites of fenestration were recorded.

A certified canine rehabilitation practitioner provided physical rehabilitation. Rehabilitation protocols varied but included balance, range-of-motion, strengthening, and aquatic exercises. Aquatic therapy consisted of either controlled swimming in a large therapy pool or use of an underwater treadmill. The patients’ neurological status, and degree of improvement was evaluated at each therapy session. Physical therapy sessions usually consisted of a weekly one-hour regimen directly conducted or supervised by the rehabilitation practitioner. The patients commonly underwent a six-week programme, but additional visits were assigned at the attending surgeon’s discretion.

When necessary a telephone interview was conducted with the referring veterinarian for follow-up information.

**Statistical analysis**

A Cox proportional hazards model was fitted to model time-to-event (ambulation) data including information from censored cases which left the study before a definitive outcome was reached (12). Ambulation as the event following surgery was defined in two ways. One approach was to define this event as dogs who experienced any form of ambulation during postoperative evaluations being either weakly or strongly ambulatory. The other approach was to limit the definition of the ‘outcome event’ to only those dogs which were graded as being strongly ambulatory. The method for including covariates in the models was a forward step-wise procedure with testing for entry of a variable based upon the significance of the score test statistic ($P\leq0.05$) and testing for removal based upon the probability of a Wald statistic based on maximum likelihood estimates ($P>0.10$) (13). A log minus log survival curve was plotted to check the proportion hazards assumption. Only dogs with complete data for case outcome and all risk factors considered were included in analysis. For all of the analyses the statistical significance was set at $P<0.05$. Chi square or Fisher’s exact tests were used to evaluate associations between variables collected from the medical records and outcomes related to upper or lower motor neuron involvement, ambulation, euthanasia, or being lost to follow-up. For some evaluations, the values of variables were transformed to create discrete categorical variables with two outcome values. Kendall’s tau-b test was used to evaluate association between deep pain as an ordinal variable with three categories (none, questionable, or present) and upper or lower motor neuron involvement.

**Results**

Three hundred and eight dogs met the criteria for inclusion into the study. Of the 308, 250 cases had complete data sets and follow up information available. Thirty-one cases were excluded due to lack of follow up
information. Six of the 250 (2%) cases were euthanatized due to lack of improvement of neurological status within the first postoperative month.

Intervertebral disc space did not have any effect upon the ‘outcome event’ defined as dogs that were either weakly or strongly ambulatory following surgery. Overall, 222 of 250 (89%) cases experienced ambulation during the study follow-up period.

There were 28 cases that were censored before ambulation was observed including six cases that were euthanized between one and four weeks after surgery. The other 22 dogs did not display any ambulation at their last examination which ranged from two to 32 weeks following surgery with all but four of these dogs having their last examination at four weeks or later. Deep pain status was the only variable selected for inclusion in the model as having a significant association with outcome and time to ambulation (P = 0.02).

The presence of deep pain perception prior to surgery was evaluated as absent in 25/250 (10%), questionable in 7/250 (3%), and present in 218/250 (87%) of the cases. Two of the 25 patients without any deep pain perception were euthanatized within the first postoperative month. Of the 23 patients assessed as having absent deep pain perception 18 (78%) regained the ability to ambulate. Four of the seven (57%) patients that had questionable deep pain perception regained the ability to ambulate. Overall, 69% (22/32) of the patients that were assessed as having either absent or questionable deep pain perception became ambulatory at some point postoperatively. Ninety-two percent (200/218) of patients assessed preoperatively as having deep pain perception returned to ambulation.

Although deep pain was coded with either three values (absent, questionable, or present) or with two values (absent or questionable deep pain combined into one category), the variable coded with two values was selected as having the best fit for the model. Dogs with deep pain present preoperatively had a 1.7 times better chance for becoming ambulatory compared to dogs without deep pain perception.

There was a marked increase in the percent of ambulatory patients between two and four weeks. Forty-two percent (104/250) of all patients were ambulatory at two weeks, and 79% (198/250) of patients were ambulatory by four weeks postoperatively. At two weeks, 34% (11/32) of patients without deep pain perception were ambulatory while 47% (102/218) of patients with deep pain perception were ambulatory. These percentages increased to 59 and 82%, respectively, at four weeks (Fig. 1).

All other variables, including host factors (age, sex, weight, breed), steroid medication pre- or postoperatively, previous spinal surgery history, and physical therapy postoperatively, did not significantly influence time to ambulation in the Cox proportional hazards model. Based upon examination of the log minus log survival curve, the proportional hazards assumption for this model was satisfied.

For the analysis limited to an outcome defined as strongly ambulatory, there were 80 cases that achieved this end point. There were 170 censored observations with 142 of these being dogs that were weakly ambulatory at the conclusion of the observation period. Three variables were included in the final model following a stepwise procedure. Categorization of spinal involvement as being either UMN or LMN was included in the model (P = 0.03). Deep pain categorized as being present or as being either absent or questionable was also included in the model (P = 0.03). The age was included in the model as a continuous variable (P = 0.01). For an incremental increase in age of one year, there was a 0.90 times chance for a dog to be strongly ambulatory compared to the younger age status. For the dichotomous variables, LMN involvement and presence of deep pain were associated with 2.0 and 2.8 times greater chances, respectively, for being strongly ambulatory postoperatively compared to dogs which lacked these characteristics. For dogs with LMN involvement, more than half (59%) became strongly ambulatory by four weeks postoperatively while only 49% of dogs with UMN involvement became strongly ambulatory by six weeks, with age and deep pain being evaluated at mean values of 6.0 years and 87% frequency of deep pain (Fig. 2).

For this analysis, other variables were not significantly related to the time required to become strongly ambulatory. The proportional hazards assumption for this model was satisfied based upon examination of the log minus log survival curves for the variables included in the final model. Age was evaluated by using category values of <7 and ≥7 to develop the log minus log survival curve. A summarisation of the patient’s DPP status, LMN vs. UMN status, and time to ambulation is noted in Table 1. There were no significant associations identified be-
tween dogs with UMN or LMN involvement and age (<7 yr. or ≥7 yr.), weight (<20 lb. or ≥20 lb.), breed (Dachshund or Beagle vs. other breeds), preoperative neurological status (deep pain perception), preoperative or postoperative corticosteroid therapy, side of hemilaminectomy, postoperative physical rehabilitation, or previous hemilaminectomy (P=0.05). The comparison with the strongest evidence for an important association with UMN or LMN involvement was for weight categorized as <20 or ≥20 lb. (P=0.06). However, in this situation, dogs with LMN involvement tended to be heavier (53%) compared to dogs with UMN involvement (30%). This tendency would perhaps have favoured recovery of dogs with UMN if there were any advantage associated with weight related to UMN or LMN involvement. The association of UMN or LMN involvement with preoperative neurological status was not significant whether deep pain was categorized as a two-way (absence/questionable vs. present DPP) or a three-way variable (absent, questionable, or present) [P=0.71 and 0.26 respectively].

The breed was not significantly associated with time to ambulation nor with the ambulatory outcome status. The Dachshund was the most common breed affected in this study comprising 56% (141/250) of the cases. Beagles were the second most affected breed representing 8% (21/250) of the cases. The age at the time of surgery ranged from one to 14 years of age with a mean of 6.0 years (SD =2.9 years). Eight of the dogs were intact females, 102 were spayed females, 24 were intact males, and 116 were neutered males. The weight at the time of presentation was 8.9 kg ± 5.0 kg (mean ± SD). In none of the analyses, age, sex, or weight was a significant factor for the ability to ambulate or the time to ambulation.

The most common intervertebral disc space affected was T12–13 at 26%, followed by T13–L1 at 21%, and T11–12 at 18%. In this study, 81% of the cases had disc extrusions between T11–12 and L1–2. There were 24 cases (8%) which had herniations at or caudal to L3–4.

The side of the hemilaminectomy was left in 129/250 (52%), right in 102/250 (41%), and bilateral in 19/250 (8%). Of the 19 bilateral hemilaminectomies performed, disc material was identified on the left side in three cases and on the right side in six cases. The remaining 10 cases had equal amounts of disc material identified on both sides. There was not any significant difference in the ability to regain ambulation or time to ambulation when compared to the side of herniation.

Corticosteroids were administered preoperatively in 225 cases and postoperatively in 193 cases. There was no significant difference in the ability to regain ambulation or time to ambulation between dogs that were treated with corticosteroids pre- or postoperatively compared to those patients that did not receive corticosteroid therapy.

Twenty-one patients had a lateral disc fenestration performed at the time of surgery. Of these patients, 17 cases had only the extruded disc site fenestrated and three cases had the immediately adjacent discs fenestrated in addition to the extruded disc site. One patient had only the site adjacent to the hemilaminectomy fenestrated. There was no significant difference in time to ambulation or the ability to regain ambulation between

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<th>Table 1</th>
<th>A summary of the patient’s DPP status, LMN vs. UMN, and time to ambulation.</th>
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<tr>
<td>DPP</td>
<td>LMN</td>
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<tr>
<td>- DPP</td>
<td>25*</td>
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<td>? DPP</td>
<td>7</td>
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*2 cases euth.
dogs that either had or did not have disc fenestration at the time of surgery.

Seventeen of the 250 (7%) cases had had previous hemilaminectomies performed. Three of the 17 (18%) patients had a disc extrusion at the previous hemilaminectomy site and six (35%) had another disc extrusion in a site immediately adjacent to the previous hemilaminectomy site. Eight (47%) cases had another disc extrusion two or more disc spaces away from the previous extrusion site. There was no difference in time to ambulation, or the ability to regain ambulation, between the dogs that had had previous hemilaminectomy surgery, and those patients that had not undergone previous hemilaminectomy surgery.

Only 22 patients underwent physical rehabilitation. Of the 22 patients, 17 (77%) regained the ability to ambulate. A significant difference was noted between the dogs that had physical rehabilitation postoperatively and time to ambulation or the ability to regain ambulation.

Discussion

The affected intervertebral disc space did not have any effect on ability to ambulate or the time to ambulation in this study. This is the first study reported to examine specific intervertebral disc spaces, associated with Hansen Type 1 disc extrusions, as a prognostic indicator relative to return to function and the time to return to function. Many reports suggest that lesions in the caudal lumbar spine from intervertebral disc herniations justify a poorer prognosis (9–11). The poorer prognosis was attributed to the potential damage to the lumbosacral intumesence.

Our study characterised initial ambulatory status into either ‘weak’ or ‘strong’. This was done to further identify potential factors that may alter neurological recovery. Contrary to the aforementioned previous reports, our study did demonstrate a significant likelihood that those patients presenting with UMN lesions were 2.0 times more likely to regain strong ambulatory status sooner when compared to patients with UMN lesions. Our study does agree with one previous study suggesting there was no difference in the ability to regain ambulatory status between patients with UMN and LMN lesions (9). That study did not specifically examine disc spaces relative to strong vs. weak ambulatory status. It is possible that the spinal cord has more mobility and/or space in the lower lumbar region. Another possibility is a higher velocity of disc extrusion near the thoracolumbar junction due to a ‘stress riser’ effect. The lack of any significant differences based upon tests of association between UMN or LMN involvement and other variables from the medical records, including preoperative neurological status, indicated that UMN or LMN involvement was not likely related in any important way to other potentially significant explanatory variables which might have been a source of bias in the results.

The significant effects of age and deep pain perception on strong ambulatory status noted in our study, are similar to previous reports (2, 4, 5, 8, 14). Again, these studies did not subdivide ambulatory patients into weak vs. strong. Our study found increasing age had a negative effect on strong ambulatory status. This finding may be due to overall decreased mobility associated with age-related musculoskeletal disease or other unidentified diminished recovery capabilities.

Previous studies have stated an average time to ambulation ranging between seven and 13 days (1, 7, 9). Our study suggests that many patients will regain ambulatory status two to four weeks after surgery. However, our patients’ ambulatory status continued to improve during the eight and 12 week follow-up periods. This finding agrees with a recent study showing mean time to ambulation of 7.5 weeks with 62% of dogs walking within four weeks after surgery (8). Patients regaining ambulatory status within the first month presumably have suffered less severe spinal cord damage.

The presence or absence of deep pain perception has been widely accepted as an important prognostic indicator. Our study showed that those patients without deep pain perception were 1.7 times less likely to become ambulatory. Our study also showed that 69% of those patients that were assessed preoperatively as having absent deep pain perception returned to ambulation. The reported recovery rates for patients with preoperative absent deep pain are between 0–76% (4, 8, 14).

The assessment of deep pain is a clinically subjective manipulation that requires interpretation by the examiner. The examiner will look for a visible pain response. The patient’s response to painful stimuli may be subtle, and certainly the interpretation of the response may vary between examiners. Actual measurement of impulse conduction in non-myelinated nociceptive spinal cord neurons is not clinically practical. While our study demonstrated that the presence or absence of deep pain perception had a significant influence on the ability of the patients to regain ambulatory status, and the time to ambulation, it should be noted that a relatively high percentage of patients assessed as not having deep perception pain prior to surgery did recover.

In our study, 7% of patients had had previous hemilaminectomy surgery. This finding is similar to a recent report (15). Our study showed that nearly half of these cases had their second disc extrusion at least two disc spaces distant from the original extrusion. This finding is in contrast to the aforementioned report in which nearly half of the cases requiring a second laminectomy had disc extrusions immediately adjacent to the original site (15).

The number of patients in the present study recorded as having postoperative physical rehabilitation was low accounting for only 7% of the study population. Of these patients undergoing physical rehabilitation, 77% regained the ability to ambulate. Further study is needed to identify the effects of physical therapy on these patients.

Conclusion

This is the first study reported to examine specific intervertebral disc spaces as a prognostic indicator relative to return to function and the time to return to function. Our findings suggest that there is no regional effect on the overall ability to regain ambulatory status, or time to ambulation, associated with Hansen Type 1 disc extrusions in the thoracolumbar and lumbar spinal column.
The patients with disc extrusions at or caudal to L3–4 were twice as likely to achieve strong ambulatory status sooner than those patients with disc extrusion between T10-L3. Increasing age had a negative effect on regaining strong ambulatory status. However, age did not affect the overall ability to regain ambulatory status. Patients assessed preoperatively as having absent deep pain perception were slower to regain ambulatory status, and 1.7 times less likely to regain the ability to ambulate. Those assessed without deep pain preoperatively still had a 69% recovery rate in ambulatory status.

References


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