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ORIGINAL ARTICLE

Canine thoracolumbar intervertebral disk herniation and rehabilitation therapy after surgical decompression: A retrospective study

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ABSTRACT

Objective: The purpose of this study was to evaluate the clinical outcome of surgical decompression and rehabilitation therapy in dogs with thoracolumbar intervertebral disk herniation (IVDH).
Materials and Methods: After surgery, physiotherapeutic rehabilitation was performed by a combination of electrotherapy, infrared therapy, training for standing, deep tendon reflex, and aquatic treadmill exercise. A total of 186 dogs were selected from the hospital records and included in two groups: the rehabilitated group (RG, n = 96) and non-rehabilitated group (NRG, n = 90). Dogs in each group were subdivided into three groups based on a pre-operative clinical severity grading system and those in grades 2–4 were included in this study. Post-operative neurologic functions, unassisted standing, walking, and the success rate of both groups were evaluated and compared
Results: Overall, 86.46% (83/96) of dogs had a successful neurologic outcome in the RG group, which was significantly ($p < 0.01$) higher than the NRG group 52.22% (47/90). Interestingly, the success rate differed when the preoperative grading system was considered. The success rates of grades 2, 3, and 4 were 97.14% (34/35), 97.33% (42/45), and 43.75% (7/16), respectively, in the rehabilitated groups, whereas in the non-rehabilitated groups, success rates were 82.35% (28/34), 51.85% (14/27), and 17.24% (5/29), respectively. The differences in success rates among the groups according to grading were 14.79%, 41.48%, and 26.51%, respectively, indicating that the proposed rehabilitation therapy is remarkably advantageous for increasing the success rate.
Conclusion: Rehabilitation therapy after surgical decompression of thoracolumbar IVDH improves neurologic functions and increases the success rate, especially when the preoperative pathological condition is severe.

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Neurologic outcome; neurologic grading; exercise; electrotherapy, infrared therapy.

Introduction

Intervertebral disks are fibrocartilaginous pads between each of the vertebrae in the spinal column, which play an important role in regulating slight movement, flexibility, and stability of the spinal column and in holding the vertebrae together, in addition to acting as shock absorbers. Each disk consists of fibrous outer rings and a nucleus pulposus. Intervertebral disk herniation (IVDH) is a pathological condition in which abnormal herniation or bulging of the central nucleus portion of an intervertebral disk occurs through the damaged portion of the outer rings [1]. If the disk protrusion is large enough, it can press on the adjacent spinal nerves, resulting in severe injury, pain, and neurologic abnormalities in generating and propagating action potentials [2]. IVDH is a common disorder of the vertebral column in all types of dog breeds [3–5]. There are two types of IVDH; Hansen type-I and Hansen type-II IVDH. Hansen type-I can be defined as a complete rupture of the dorsomedian (left) or dorsolateral (right) annulus fibrosus (AF) and dorsal longitudinal ligament (DLL) with extrusion of degenerated nucleus pulposus (NP) material and it most commonly affects

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chondrodystrophic dog breeds. Hansen type-II IVDH can be defined as partial ruptures and disorganization of the AF, and bulging of the NP, AF, and DLL toward the dorsomedian (left) or dorsolateral (right) side. It is commonly observed in nonchondrodystrophic dog breeds [1,6]. However, it has been reported that the percentage of IVDH in the Dachshund breed is higher than in other chondodystrophic dog breeds [3,6–8]. The occurrence may differ depending on the region and it is important to report which breed may be most susceptible in each region; therefore, this paper is focused on susceptibility in Korea. Clinical signs of thoracolumbar IVDH include back pain, paraparesis (ambulatory or non-ambulatory), paraplegia, muscle electricity and tone alteration, urinary dysfunction, and loss of deep nociception [4,5].

Surgical procedures to correct IVDH include hemilaminectomy, mini-hemilaminectomy, dorsal laminectomy, and corpectomy or disk fenestration [3,9–11]. The methods can be applied based on the causes and the affected site and pathological conditions of the IVDH. The objective of these surgical procedures is to relieve pain and neurologic disorders by surgical decompression of the spinal cord or nerve. Several studies have reported that surgery alleviates pain intensity and corrects neurological deficits, and overall functional success has been reported in 70%–90% of cases [8,12,13], and the recurrence rate was observed to be 20%–28% in dogs [13]. Furthermore, many of these survival dogs suffer from lack of strength and quadrupedal coordination [14]. These results indicate the importance of a physiotherapy program to overcome this problem. In veterinary practice, there are few reports about the effect of physiotherapy rehabilitation for dogs with disk disease and the reports have conflicting findings after surgical intervention [14–16]; the findings have indicated no effects in recovery-related variables among dogs after physiotherapy [15], improved neurologic function, reduced postoperative complications [16], and safe procedures that did not improve the rate or influence recovery level [14]. The various clinical outcomes of these reports might be due to variation in physiotherapeutic content and techniques. Moreover, there is a scarcity of well-defined structured physiotherapy programs. Few reports are available from prospective randomized studies on patients with thoracolumbar IVDH that have received decompressive surgery with long-term follow-up and functional measurements [3,11].

To the best of authors' knowledge, there are no recent reports on the surgical management of thoracolumbar IVDH in dogs with physiotherapy with a comparison of the neurologic outcomes of the non-rehabilitated group. Therefore, the main objective of this study was to investigate the benefits of well-structured rehabilitation physiotherapy after surgery for thoracolumbar disk disease and to retrospectively compare neurologic function over 5 years (2012–2017.05) to improve understanding as well as long-term outcomes.

Materials and Methods

Case history and case selection

The clinical record database of the neurology unit at the Royal Animal Medical Center (RAMC) was searched for dogs with a diagnosis of thoracolumbar IVDH between 2012 and 2017. The extracted information included breed, age, sex, body weight, clinical history, neurological status, radiographs, CT, MRI, anatomic localization of the IVDH, surgical procedures, rehabilitation therapy, and the final clinical outcome. Post-surgery recovery depends on the patient's pre-surgery pathological condition; therefore, putting all patients with different pathologic conditions in the same group is not recommended. Based on this data, four groups of dogs were carefully arranged based on the historical hospital records, which were assessed by veterinary surgeons at admission, according to the severity of neurological dysfunction based on a grading system [17]. Briefly, the grading system assignments were; 0, for normal; 1, single or occasional mild, moderate, or severe back pain, present or absent slight conscious proprioception (CP) deficits, no motor weakness; 2, persistent and severe back pain, CP deficits, ambulatory paraparesis; 3, uncontrolled severe back pain, CP deficits, weak ambulatory paraparesis, or non-ambulatory paraparesis; and 4, paraplegia with or without deep-pain perception. Only dogs designated as grades 2–4 were recommended for surgical decompression and included in this study, whereas grade 1 dogs that were recommended for conservative therapy and were excluded from this study. The case selection, separation, and treatment procedures were performed as shown in Fig. 1.

The clinical cases were diagnosed and surgical treatment approaches were decided by the expert veterinary surgeon at a team meeting at the Royal Animal Medical Center, the Committee for the Care of Animal Resources approved all protocols employed herein (Approval number: RAMC IACUC 17-KE-011; 02 Jan 2012).

Diagnosis

A presumptive diagnosis was initially made by physical examination of clinical signs, symptoms, and clinical history. A confirmatory diagnosis was made by complete diagnostic imaging reports, including survey radiographs, and MRI or CT-scan (Fig. 1). Dogs that were followed-up for 5 months were included. Radiography by Titan 2,000 (COMED Medical Systems CO. Ltd., Seoul, Korea) was done and interpreted for all animals. CT imaging was performed using an ECLOS 16-row detector CT scanner (Hitachi, Tokyo, Japan) and MRI was performed (GE healthcare, New York, NY, USA) to exclude other pathological abnormalities.

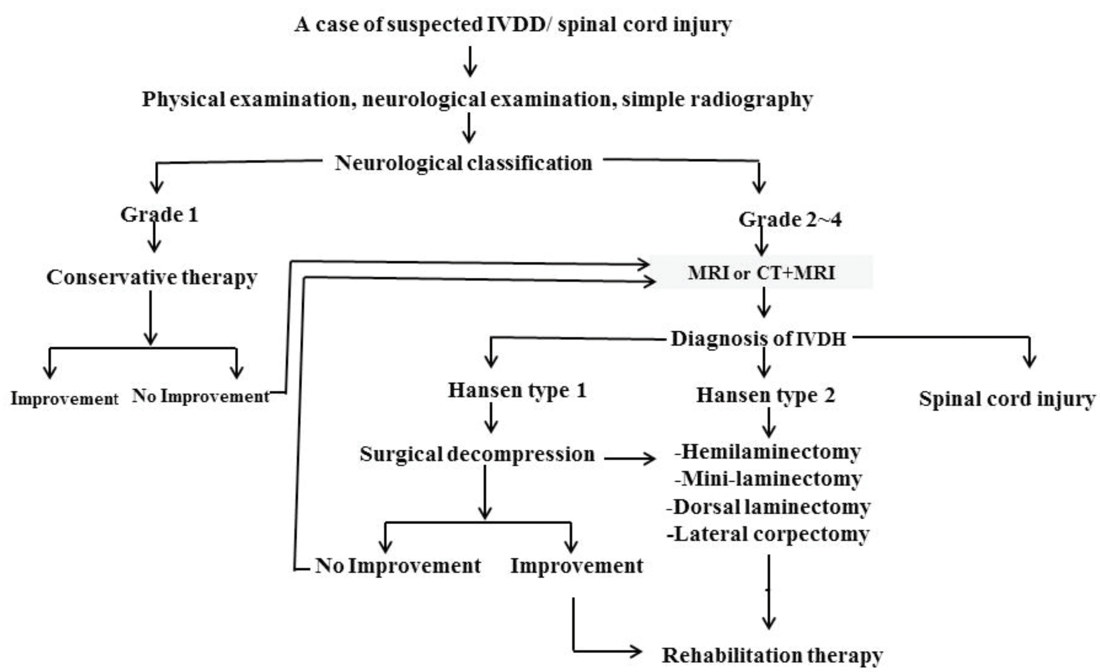

Figure 1. General characterization for the surgical treatment, case selection, separation, and rehabilitation therapy for dogs with thoracolumbar IVDD.

Surgery and neurologic outcome evaluation

General anesthesia was administered via a slow intravenous injection of propofol 6–8 mg/kg, and sevoflurane (1%–5%) was used to maintain anesthesia [5]. Positive pressure was maintained by a ventilator, and ECG and end-tidal CO_2 were monitored automatically by an automated anesthetic machine (PAIEON, J & TEC, Goyang-Si, Gyeonggi-do, South Korea) during surgery [18–20]. In preparation for surgery, intravenous (IV) 0.9% normal saline, cephradine, tramadol, and steroid dexamethasone or methylprednisolone sodium succinate were administered as described previously [5]. After shaving the entire back region, aseptic preparation, clipping, and draping were performed. The animal was positioned in ventral recumbency. A dorsolateral approach to the spine was used for hemilaminectomy. Following the dissection of subcutaneous tissue, the affected part of the vertebral joint was exposed, and the herniated part of the disk was corrected by hemilaminectomy [21], dorsal laminectomy [22], or partial lateral corpectomy [17,23], as described elsewhere. The surgical technique selection was based on the surgeon's preference with consideration of preoperative clinical, pathological, and imaging findings. The surgical procedures were performed by the same surgeon but using different methods, that included hemilaminectomy, mini-hemilaminectomy, dorsal laminectomy, disk fenestration, corpectomy, or two combined methods, depending on the location of disk herniation or for appropriate decompression. The dogs were discharged from the hospital after 7–14 days post-operative care, depending on the dog's condition. However, the dogs in the rehabilitation group (RG) were admitted to the Rehabilitation Department only when the owner agreed to pay an additional amount and the non-rehabilitated group (NRG) was kept free from any rehabilitation therapy due to the owner's lack of interest. The animals were kept in an intensive care unit for 4 days for close observation for vital signs and adequate analgesia for symptoms, such as local pain or clinical discomfort. Postoperative therapy with fluid therapy, medications such as enrofloxacin, cephradine, tramadol, and corticosteroids were administered, as described previously [5]. All animals were released from the hospital after 7–14 days and made full recoveries. The neurologic outcome was assessed by unassisted standing time and walking time [5] as well as the Olby score (OS) based on neurologic examinations, as described previously [24] and the score was recorded at five time points (before surgery and 7 days, 14 days, 1 month, and 3 months after surgery) (Fig. 2). The patients were also followed for postoperative complications that recorded long-term (follow-up by telephone or physical exam for 5 months after surgery) morbidity and any recurrence as documented by referring veterinarians.

The neurologic functions that were assessed included the ability to stand and walk unassisted, and resolution of pain. Moreover, the final clinical outcome at the time of discharge was performed, as described previously [4,5,12]. The outcomes were defined as: excellent, when dogs were neurologically normal; good, when the postoperative neurologic grade was improved from the preoperative condition and had improved sufficiently to require minor or no therapy after discharge; fair, when the postoperative neurologic status was unchanged from the preoperative condition; and poor, when a major postoperative complication had developed, and as a consequence, the neurologic grade had become worse at discharge than the preoperative score, or if another clinical disability that was present at admission had developed, or the patient had died. The percentage of the success rate was calculated by the following equation: (Excellent + Good)/Total animals $\times$ 100 [5].

Physical therapy and rehabilitation

Three types of physical examination were performed prior to physical therapy: (a) assessment of the muscle strength of the hind limbs and tonicity with the MyotonPRO (Myoton AS, Tallinn, Estonia) technique to measure muscle tone in the hamstring and quadriceps (Fig. 3A and B); (b) assessment of superficial and deep pain in the limb by a needle or finger, and determining the stage of the OS (Fig. 2); and (c) assessment of the patient's ability to stand. The intensity and duration of physical therapy were determined based on the animal's condition which impacted the recommended rehabilitation approach, as described below, to improve neuromuscular function, as described previously [5].

1) **Electrotherapy:** The objective of electrotherapy is to restore muscular function. The intensity of the initial electricity was determined (10–20 mA) based on the health status of the animal and was gradually increased within parameters (30–45 mA) until sufficient muscle shrinkage was observed. Electrotherapy was applied twice daily for 30 min and was performed with a PORTABLE TENS LT1061 (Shenzhen Dongdixin Technology Co., Ltd, Shen Zhen, China). After shaving, therapeutic patches were fixed with Sonogel to the quadratus lumborum, quadriceps, and cranial tibialis muscles of both hind limbs.
2) **Infrared (IR) treatment:** IR irradiation were performed at 800 nm to 1200 nm for 0–15 min twice daily to the paralyzed area to increase blood flow. The irradiated area was periodically checked to prevent burning.
3) **Standing training:** The dogs were passively trained to stand. A passive standing posture was created with tools such as slings and balls. The standing time was gradually and proportionately increased until the animal habituated. The training time was scheduled for 15–20 min.
4) **Balance board training:** The training was conducted when the animal was capable of unassisted standing or could walk voluntarily but lacked a sense of balance. The animal was placed on the board to maintain height and posture reflexes to enhance the nervous system recovery. Training sessions lasted 15–20 min and were carried out twice a day.
5) **Deep tendon reflex (spinal reflex) stimulation:** Deep tendon reflex (spinal reflex) stimulation can stimulate the $A\alpha$ nerve fibers and $A\gamma$ nerve fibers by sustaining stimulation of the deep tendon reflexes to help restore the nerves and muscles, thereby, improving disability. The deep tendon reflex stimulation was done for 12–20 min per day.
6) **Aquatic treadmill exercise (ATE):** The aquatic treadmill exercise was used when the animal was capable to some extent of standing and walking. The exercise was started at a lower speed and gradually increased, depending on adaptation. Initially, the amount of water in the treadmill was filled up to the height of the hip joint and was gradually reduced, depending on performance.

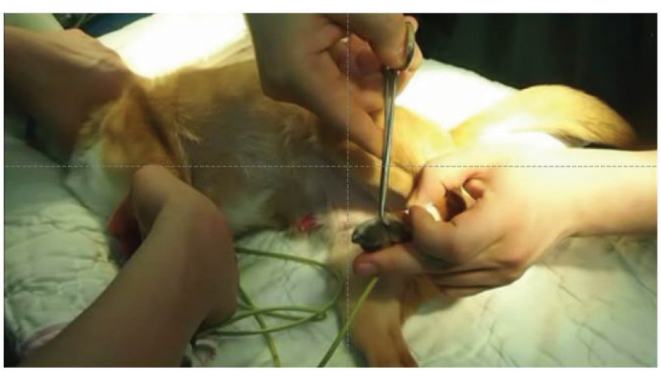

Figure 2. Evaluation of neurologic status in the hind limbs with the Olby scoring technique.

Figure 3. Muscle tonicity in the hind limb measured by the MyotonPRO technique. A: measurement of muscle tone from the hamstring muscle; B: measurement of muscle tone from the quadriceps muscle.

Statistical analysis

Data were analyzed by a Bonferroni post hoc test following one-way analysis of variance (ANOVA) or two-way ANOVA for the NRG vs. RG groups using Prism 5.03 (Graph Pad Software Inc., San Diego, CA). The results were expressed as mean ± standard error of *mean* (SEM) or proportion and were considered statistically significant when $p < 0.05$. Percentages of data were analyzed using a two-sample proportion test with Minitab software (version 16.1) to evaluate any significant difference between the two groups.

Results and Discussion

Surgical decompression with removal of the herniated disk material is the goal of surgical treatment for IVDH with severe clinical signs. Most studies in the field have focused on surgical techniques and clinical outcomes [3,9,11]. However, recovery of neurological function in patients that have undergone surgery for thoracolumbar IVDH has not reached expected levels. Therefore, we hypothesized that dogs treated post-surgery with our specific, structured rehabilitation physiotherapy regimes might achieve better clinical outcomes compared with those treated by surgical decompression alone. Overall, in the rehabilitated group, 83/96 (86.46%) dogs were considered to have successful neurologic outcomes, 76/96 (79.17%) were excellent, 7/96 (7.29%) were good, 7/96 (7.29%) were fair, and 6/96 (6.25%) had poor results (Fig. 4, Table 1). In comparison, in the non-rehabilitated group, 47/90 (52.22%) dogs were considered to have successful neurologic outcomes, 20/90 (22.22%) were excellent, 27/90 (30.00%) were good, 15/90 (16.67%) were fair, and 28/90 (31.11%) had poor outcomes.

Overall, 86.46% (83/96) of the dogs had a successful neurologic outcome in the RG group, which was significantly ($p < 0.01$) higher than the NRG group 52.22% (47/90). Interestingly, we found that the success rate differed when the preoperative grading system was considered, even after rehabilitation therapy. The success rates of grades 2, 3, and 4 were 97.14% (34/35), 97.33% (42/45), and 43.75% (7/16), respectively, in the rehabilitated groups, whereas in the non-rehabilitated groups, success rates were 82.35% (28/34), 51.85% (14/27) ($p <$

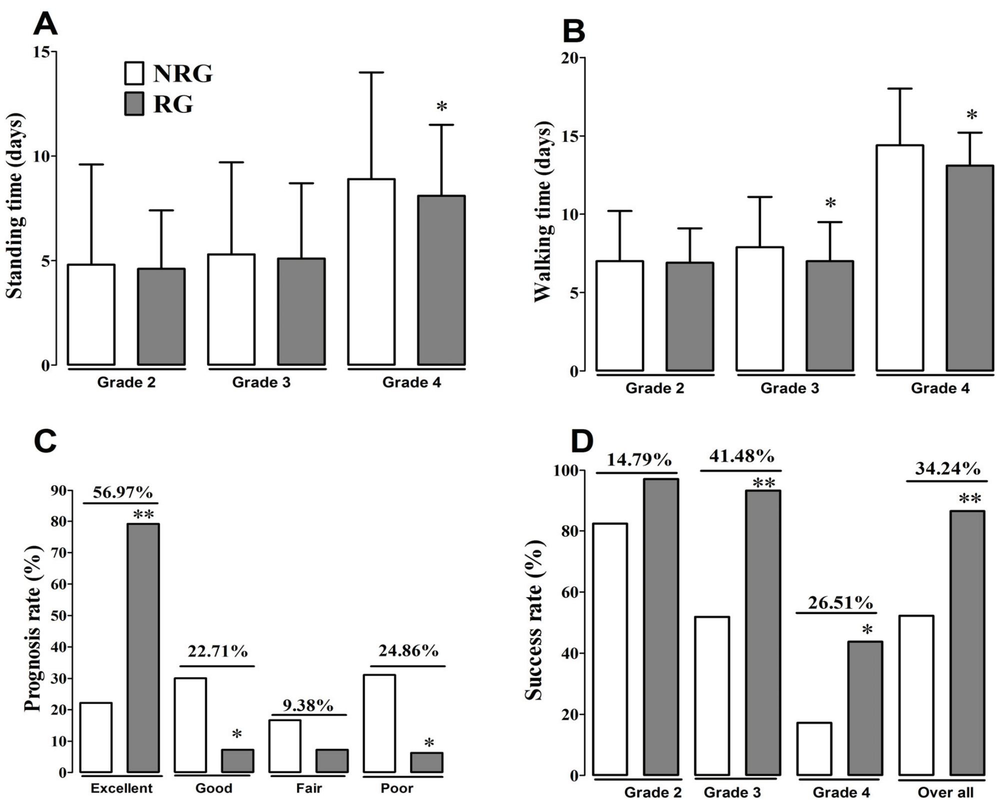

Figure 4. Comparison of standing time, walking time, and success rate between the rehabilitation and without rehabilitation groups. NRG: non-rehabilitated group; RG: rehabilitated group. The data are reported as the mean ± SEM *, $p < 0.05$; **, $p < 0.01$, Bonferroni post hoc test following one-way ANOVA versus the NRG group. Percentages of data were analyzed using a two-sample proportion test with Minitab software (version 16.1) to assess any significant difference between the two groups.

Table 1. Post-operative clinical outcomes for dogs with thoracolumbar intervertebral disk herniation with rehabilitation based on pre-operative grading score.

Grade	Surgical result	Case	Mean standing after surgery (days)	Mean walking day after surgery (days)	Recovery percentage
2 (n = 35)	Excellent	31	4.6 ± 2.8	6.9 ± 2.2	97.14%
	Good	3			
	Fair	1	No improvement		
	Poor	0	Dead		
3 (n = 76)	Excellent	40	5.1 ± 3.6	7.0 ± 2.5	93.33%
	Good	2			
	Fair	1	No improvement		
	Poor	2	Dead		
4 (n = 16)	Excellent	5	8.0 ± 3.4	13.0 ± 2.10	43.75%
	Good	2			
	Fair	5	7 days (body only), 14 days (body only), (no walking)		
	Poor	4	Dead		

Table 2. Post-operative clinical outcomes for dogs with thoracolumbar intervertebral disk herniation without rehabilitation therapy, based on pre-operative grading score.

Grade	Surgical result	Case	Mean standing after surgery (days)	Mean walking day after surgery (days)	Recovery percentage
2 (n = 34)	Excellent	16	4.7 ± 4.8	7.0 ± 3.2	82.35%
	Good	12			
	Fair	3	No improvement		
	Poor	3	Dead		
3 (n = 27)	Excellent	4	5.3 ± 4.4	7.9 ± 3.2	51.85%
	Good	10			
	Fair	8	No improvement		
	Poor	6	Dead		
4 (n = 29)	Excellent	0	8.9 ± 5.1	14.4 ± 3.6	17.24%
	Good	5			
	Fair	4	7 days (body only), 14 days (body only), (no walking)		
	Poor	20	Dead		

0.01), and 17.24% (5/29) ($p < 0.01$), respectively. The differences in the success rate among the groups according to grading were 14.79%, 41.48%, and 26.51%, respectively (Fig. 4; Table 2). Moreover, the groups with rehabilitation had significantly shortened unassisted walking and standing times, compared with the NRG (Fig. 4; Table 1). The post-operative times until unassisted standing in the rehabilitated dogs in grades 2, 3, and 4 groups were 4.6 ± 2.8, 5.1 ± 3.6, and 8.0 ± 3.4 days, respectively. The times until unassisted walking in the same group and grades were 6.9 ± 2.2, 7.0 ± 2.5, and 13.0 ± 2.10 days, respectively (Table 1). The post-operative times until unassisted standing of the non-rehabilitated dogs with grade 2, 3, and 4 were 4.7 ± 4.8, 5.3 ± 4.4, and 8.9 ± 5.1 days and the times until unassisted walking were 7.0 ± 3.2, 7.9 ± 3.2, and 14.4 ± 3.6 days, respectively (Table 2). The group that received rehabilitation recovered faster than the group that did not receive rehabilitation (Fig. 4). These findings indicate that prognosis depends on preoperative neurological status and that rehabilitation therapy can increase the success rate and ameliorate neurologic functions.

In addition, the OS was measured until 3 months after surgery for five dogs in each group for grade 2 (n = 10; R = 5, NR = 5), grade 3 (n = 10; R = 5, NR = 5), and grade 4 (n = 10; R = 5, NR = 5) for both rehabilitated and non-rehabilitated animals (Fig. 5). Therefore, the total number of dogs from the rehabilitated group was 15 and that of the non-rehabilitated group was 15. Thus, the total number of animals with a 3-month post-operative OS was 30. Three months post-surgery and with physiotherapy, the OSs were 14 for three dogs, 13 for one dog, 12 for one dog, 11 for one dog, 10 for two dogs, 9 for six dogs, and 8 for one dog. In contrast, the dogs in the rehabilitation group (n = 15) were assessed for 3 months. The 3 months post-operative OSs were 14 for eight dogs, 13 for six dogs, and 12 for one dog. A gradual improvement in neurologic outcomes was found to be significant in the rehabilitated group; therefore, rehabilitation aids in a faster recovery. The OS of the pre-surgery ambulatory patients was similar at 3 months with or without rehabilitation. However, the time for the rehabilitated grade 3 group to walk unassisted and the time for the rehabilitated grade 4 group to stand unassisted were significantly shorter than in the group that did not receive rehabilitation (Fig. 4).

In this study, we found that rehabilitation therapy after surgical decompression resulted in early recovery and was reflected by unassisted standing and walking and improved OS when compared with the non-rehabilitated group. The key finding of this study was that rehabilitation therapy increased the overall success rate as well as outcomes for individual preoperative grading groups. However, our results are inconsistent with previous reports [15,36] which might be due to variation in physiotherapeutic constituents and techniques but are consistent with our previous cervical IVDH report [5].

Many neuro-prostheses have been developed to improve neuromuscular system alteration which can help restore functions of the central and peripheral nervous systems through electrical stimulation, IR therapy, and exercise regimentation. Electrical stimulation is a promising technique for modulating the level of excitability, reactivating the dormant spinal neuronal circuits, and sensorimotor function after spinal cord injury [25]. Electrical stimulation has been reported to help improve the patient's neuromuscular function, and restore gait and bladder control in patients with spinal cord injuries [26]; reduce pain [26,27], enhance microcirculation, improve inflammatory processes, and influence the immune system, reparative system, and spasmolytic action. This approach has also been reported to stimulate Ca^{2+}–dependent processes and increase DNA and RNA synthesis as well as ATP synthesis and accumulation [28]. IR therapy improves wound healing, can relieve arthritic knee pain, chronic back pain, and the endorphin levels [29], and can delay paralysis in patients with spinal problems [30]. When the animal was able to stand up, we applied ATE, which allowed the dog to walk comfortably on a treadmill in water. This approach allows for earlier limb movements in the recovery period compared with performing the exercise on land [31,32]. ATE improves recovery of locomotor function through axonal regeneration and enhances brain-derived neurotrophic factor expression in the spinal cord of injured rats, thereby contributing to neuronal integrity [33]. Therefore,

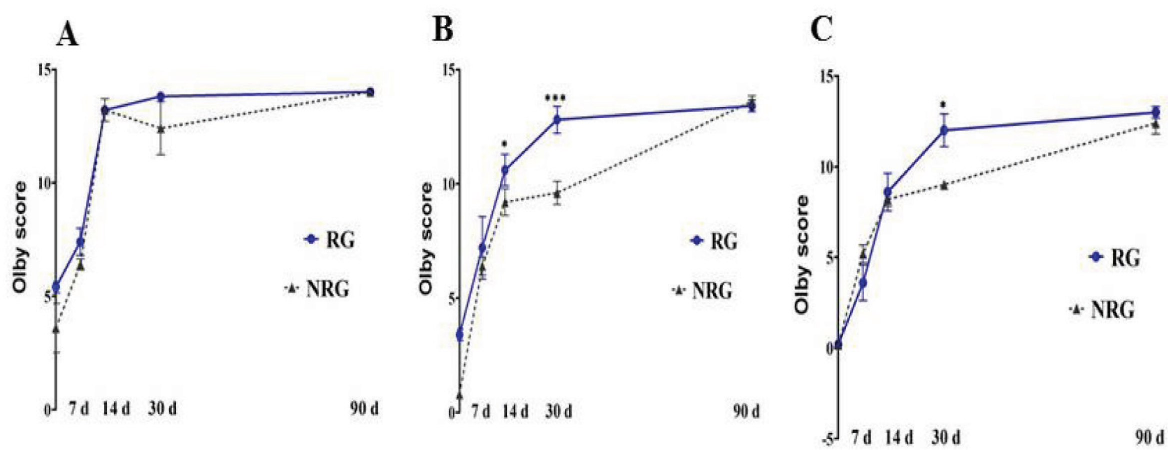

Figure 5. Gradual changes in improving neurologic outcome (n = 15) of dogs after surgical decompression of intervertebral disk herniation with or without rehabilitation therapy (before and after surgery until 90 days). The data are reported as the mean ± SEM *, $p < 0.05$; ***, $p < 0.001$, Bonferroni post hoc test following two-way ANOVA versus the NRG group. NRG: non-rehabilitated group; RG: rehabilitated group. A: Olby scores in preoperative grade 2 dogs; B: Olby scores in preoperative grade 3 dogs and C: Olby scores in preoperative grade 4 dogs.

surgery combined with an active structured physiotherapy program could be beneficial.

Overall, the breeds that were documented most frequently included Cocker Spaniels 35/186 (18.82%), Dachshunds 28/186 (15.05%), Maltese 23/186 (12.37%), mixed breeds 21/186 (11.30%), Pekinese 16/186 (8.60%), Poodles 11/186 (5.91%), Pomeranians 11/186 (5.91%), Shih Tzus 8/186 (4.30%), Beagles 7/186 (3.76), French Bulldogs 6/186 (3.22%), Rottweilers 5/186 (2.69%), Yorkshire Terriers 5/186 (2.69%), and other breeds 10/186 (5.38%). In this study, the most affected breed was the Cocker Spaniel followed by Dachshunds and Maltese. However, other reports have indicated that the Dachshund is the most commonly affected breed [1,3,34,35]. This result could vary from region to region, depending on the popularity and availability of certain breeds. Similar to our findings, Lim et al. [36] also found in Seoul, Korea, that the Dachshund was not the most common breed. According to their study, the most predominant breed was Pekingese (42.5%), followed by Maltese (20.0%), Cocker Spaniel (12.5%), Shih Tzu (7.5%), and Dachshund (5.0%). However, the second most prevalent breed in our study was Dachshund and the third was Maltese.

In this study, a total of 109/186 (58.60%) dogs were male (68.80% were neutered 75/109), and 41.40% (77/186) dogs were female (79.22% were spayed 61/77). The age range was 1 to 15 years and the average age of the dogs was 6.48 years. The number of dogs aged ≤4 years was 32.26% (60/186), 5–9 years was 46.77% (87/186), and dogs ≥10 years was 20.97% (39/186). The dogs had a median bodyweight of 8.24 kg (range, 2.12–21 kg). During the initial evaluation, 14.28% dogs had a history of at least one episode of clinical signs that were compatible with thoracolumbar IVDH that had been treated conservatively. The median duration of neurologic deficit prior to referral was 3 days (range, 1.5 h–32 days).

The other affected sites were T10-11 2/186 (1.08%), T11-12 15/186 (8.06%), T12-13 50/186 (26.88%), T13-L1 40/186 (21.50%), L1-2 12/186 (6.45%), L2-3 26/186 (13.98%), L3-4 13/186 (6.99%), L4-5 10/186 (5.38%), L5-6 8/186 (4.30%), L6-7 5/186 (2.69%), and L7-S1 5/186 (2.69%). The most frequent site of confirmed disk herniation was T12-13 (26.88%), followed by T13- L1 (21.50%), and L2-3 (13.98%). In this study, the T12-13 (28.57%) disk spaces were most commonly involved and then T13-L1 (24.84%) was the next most frequent affected space, which is also consistent with previous reports [17,35]; however, this was inconsistent with Lim et al. [36], who reported that the T13-L1 intervertebral disk spaces were the most affected location (30%). In the lumbar region, the L2-3 (15.53%) disk spaces were primarily affected while the L1–2 spaces were more commonly reported [17].

Conclusion

These results clearly indicate the superiority of rehabilitation therapy to no rehabilitation therapy. This study suggests that the application of physiotherapeutic rehabilitation following decompression surgery could improve clinical outcomes. In addition, the results indicated that the breeds that were primarily affected by thoracolumbar IVDH included Cocker Spaniels (18.82%) but not Dachshunds, and the most frequently affected disk space was T12-13 (26.88%) and L2-3 (15.53%) in the lumbar space.

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Conflict of interests

The authors declare no conflicts of interests.

Authors' contribution

All authors contributed equally.

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