pISSN 1598-298X / eISSN 2384-0749
J Vet Clin 36(3) : 139-144 (2019)
http://dx.doi.org/10.17555/jvc.2019.06.36.3.139

Journal of Veterinary Clinics
www.ksvc.or.kr

A Retrospective Study of Intervertebral Disk Disease Confirmed by MRI in Dogs: 89 Cases (2012-2015)

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(Received: August 29, 2018 / Accepted: June 03, 2019)

Abstract : Intervertebral disk disease is a common neurological disease in dogs. In veterinary neurology clinics, the incidence of intervertebral disk disease and the spinal cord compression rate of the disk are well documented. However, the direction of herniation of the intervertebral disk is relatively less known on Magnetic resonance imaging (MRI). Therefore, this study systematically investigated and analyzed the intervertebral disk disease in dogs. Especially, classification according to the direction of herniation of the disk, the degree of pre - treatment neurological manifestation, and the compression rate was investigated. In addition, the treatment methods of patients who received treatment after visiting the Chonbuk animal medical center (CAMC) were divided into pharmacological treatment and surgical treatment. The location of intervertebral disc in spinal canal was mainly ventral (69.9%), and when the prognosis was evaluated according to the compression rate of the spinal cord, the prognosis of the surgical treatment (72.7%) was more effective than the non - surgical medication (40.6%). Surgical treatment (83.3%) was more successful than nonsurgical medication (60%), especially in cases of severe spinal cord compression (> 50%). In this study, surgical treatment was more effective when the neurological symptoms were severe or the spinal cord compression rate was high.

Key words **:** dog, intervertebral disk disease, direction of herniation, neurological symptom, compression rate.

Introduction

Intervertebral disc disease (IVDD) is probably the most common cause of myelopathy in dogs, Intervertebral disk(IVD)s undergo degeneration with age, with regions of increased motion and stress such as the caudal cervical region, and the thoracolumbar and lumbosacral junctions undergoing the most profound changes. Hansen described types of IVD degeneration in dogs (20). Type 1 protrusions are characterized by a totally ruptured AF. Signs are acute pain and frequently paralysis as well. Type 2 protrusions are small, regularly formed bulges resulting from partial ruptures of the AF. Commonly no signs are seen (21). As a general rule, type 1 disc degeneration occurs in small breed chondrodystrophic dogs (notably the Dachshund, Labrador Retrievers, Doberman Pinschers, Chow Chows) can also be affected. Type 2 degeneration is typically associated with larger non-chondrodystrophic dogs, notably German Shepherd dogs and Doberman Pinschers (in the cervical region), but it is also common in small-breed dogs such as the Chihuahua, Yorkshire terrier, and Maltese Terrier (20).

Conventional radiography with myelography has traditionally been used for the diagnosis of IVDD, though misleading results have been reported occasionally. Recently, magnetic resonance imaging (MRI) has come into wider use in veterinary practice as a diagnostic tool. Sether *et al*. (17) determined that MRI was the best available method for early recognition of disk degeneration in dogs (3).

In previous study, extradural spinal cord compression (SCC) was located ventrally in 53% (n = 21), ventro-laterally in 45% (n = 18), and completely laterally in 3% (n = 1) of the available preoperative transverse CT myelographic images (9).The purpose of this study was to classified, retrospectively, the signalment of IVDD patient, clinical sign, disk disease type, treatment, recurrent and prognosis findings.

Material and Methods

Case selection criteria

The medical records of dogs diagnosed with IVDD at the Chonbuk animal medical center (CAMC) of Chonbuk national university in South Korea between May 2012 and October 2015 were reviewed. The dogs were diagnosed with IVDD based on signalment, clinical neurological status, radiographs and MRI. Histories and clinical signs consistent with IVDD were 89 cases were confirmed with MRI. Data obtained from medical records included breed, sex, age, body weight, onset of clinical signs, IVDD type, disk material location, localization of the affected interspace, treatment, recurrence and prognosis. Classified, according to the onset of clinical signs, as per-acute (< 2 days), acute (2-7 days), and chronic (> 7 days) (17).

Neurological deficits, as thoracic limb paresis (include plegia), pelvic limb paresis (include plegia), tetraparesis (include plegia), hemiparesis (include plegia), monoparesis (include plegia), pain and neuropathy (include seizure).

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Neurological status

The degree of neurological status was classified using a modified Frankel score: Grade (G) 0 - tetraplegia or paraplegia with no deep nociception; G 1 - tetraplegia or paraplegia with no superficial nociception; G 2 - tetraplegia or paraplegia with nociception; G 3 - nonambulatory tetraparesis or paraparesis; G 4 - ambulatory Tetraparesis or paraparesis and general proprioceptive ataxia; G 5 - spinal hyperesthesia only or no dysfunction (20). Deep nociception was assumed to be intact, if the dog exhibited a conscious response (biting, vocalizing) to the clamping of its pelvic limb digits with surgical forceps.

Magnetic resonance imaging (MRI)

Eighty-nine of 162 cases were performed magnetic resonance imaging (MRI). MRI was performed using a 0.25T (Vet Grande, Esaote, Italy) system. All animals under general anesthesia with isoflurane obtained T1-weighted image in sagittal and transverse planes, T2-weighted images in sagittal and transverse planes.

The distinguishing criteria in determining the type of lesion (Hansen type I or II) was the presence or absence of extruded disk material in the spinal canal at MRI. Extrusion describes disk material that has clearly escaped the normal boundaries of the disk and is usually significant clinically. A more reliable feature is displacement of epidural fat by extruded disk material as shown in both sagittal and transverse plane images. Extruded disk material has low signal intensity and it may alter the shape of the spinal cord in a transverse plane. The terms 'bulge' and 'protrusion' are also non-specific and a morphological description of the disk displacement is preferred (18).

Extruded or protruded disk material was localized to the ventral, ventral-left lateral, ventral-right lateral, left lateral and right lateral position. Measurements of spinal cord compression were evaluated using a 3-point scale depending on the degree of reduction of the expected normal cross-sectional spinal cord area: mild compression (< 25%), moderate compression (26%-50%), and severe compression (> 51%). The site of the affected interspace, distribution of disk degeneration and location of disk material was recorded in each dog.

Treatment

In IVDD, treatment protocols vary widely from the use of acupuncture, corticosteroids, decompressive surgical techniques, cage rest, physical rehabilitation, or a combination of the aforementioned (16). We applied treatments were nonsteroids anti-inflammatory drugs, prednisolone, acupuncture, analgesics, herb medicine, physical rehabilitation and surgery. Surgical treatments were ventral slot, hemilaminectomy, mini-hemilaminectomy, corpectomy and removed degenerated disk and leakage material. Procedure was carried out with an air speed drill and rongeuring together and minimal manipulation of the spinal cord. Corpectomy was combined with hemilaminectomy or mini-hemilaminectomy and fat tissue was implanted into the decompression defect. If the patient could not move spontaneously, physical rehabilitation was applied. Physical rehabilitation was performed as passive range of motion, water treadmill. Outcome grade classified excellent, fair, poor, euthanized, sudden death and no follow-up. Treatment failure was defined as decline or lack of improvement after treatment included fair, poor, euthanized. No follow-up included refer to local animal hospital cause by cost and distance.

Results

Signalment

Eighty-nine dogs were represented for evaluation in this study. Sixteen breeds were composed entirely, with the Maltese 22 (24.4%) and Pekingese 19 (20%) being the two most commonly represented breeds. Especially Maltese had a great portion in IVDD category (24.4%). Other breeds included Yorkshire terrier (7), Shih-tzu (7), Pomeranian (6), Mixed breed dogs (5), Cocker spaniel (5), Poodle (4), Beagle (4), Dachshund (3), Miniature pinscher (2), Jindo dog (1), Schnauzer (1), Chihuahua (1), Pug (1) and Spits (1). The age distribution in this study ranged from two years old to 16 years. The average age was 8.6 ± 3.3 years and the average body weight was 5.9 ± 3.0 kg. Distribution of sex was males accounted for 55 (61.8%) and females for 34 (38.2%) of the population. Neutered males accounted for 46 (51.7%) and spayed females for 17 (19.1%) of the population.

For animals presenting with chronic onset of clinical signs, the most common as 41 (45.6%) followed by acute 36 (40%) and per-acute 13 (14.4%). Three dogs were in neurological status G 5, 28 dogs were in G 4, 13 dogs were in G 3, 31 dogs were in G 2, 10 dogs G 1, 4 dogs G 0 (Table 1).

Results of magnetic resonance imaging (MRI)

All dogs were performed radiographs which could be considered a reason to suspect IVDD. A total of disk degeneration was identified in 225 disk spaces in 89 dogs confirmed with MRI. Thirty dogs (33.7%) had Hansen type I disk degeneration, forty dogs (44.9%) had Hansen type II and nineteen dogs (21.3%) had mixed type. In 57 of the 89 dogs (64%) with disk degeneration, multiple disk spaces were

Table 1. The Compression rate and the Neurological status for 81 dogs with intervertebral disk disease

Compression rate	Neurological status						
	Grade 5	Grade 4	Grade 3	Grade 2	Grade 1	Grade 0	Total
1-25%	1	10	6	10	2	1	30 (33.7%)
26-50%	2	13	5	9	5	2	36 (40.4%)
51-100%	0	5	2	12	3	1	23 (25.8%)
Total	3	28	13	31	10	4	89

Table 2. Location of extruded or protruded disk material

	Location of disk material					
	Ventral	Ventro-left lateral	Ventro-right lateral	Left lateral	Right lateral	Total
Number	63	11	10	3	2	89
Percentage	70.8	12.3	11.2	3.3	2.2	100

affected and thirty-two dogs (36%) were simple. Extruded or protruded disk material was localized to the ventral, ventral-left lateral, ventral-right lateral, left lateral and right lateral position in 63 (70.8%), 11 (12.3%), 10 (11.2%), 3 (3.3%) and 2 (2.2%), respectively (Table 2). Almost all cases were diagnosed as ventrally positioned. Thirty-five dogs (39.3%) compression rate was moderate, 30 dogs (33.7%) were mild and 24 dogs (27%) were severe. The most frequently affected IVD in 225 disk spaces was thirteenth thoracic to first lumbar (T13-L1) IVD space 34 (15.1%) followed by twelfth to thirteenth thoracic (T12-T13) IVD space 30 (13.3%). In 68 disk spaces at Hansen type I, most frequently affected IVD was twelfth to thirteenth thoracic (T12-T13) IVD space 18 (26.5%). In 157 disk spaces at Hansen type II, most frequently affected IVD was thirteenth thoracic to first lumbar (T13-L1) IVD space 22 (14%) followed by first to second lumbar (L1-L2) IVD space 17 (10.8%).

Cervical intervertebral disk disease

The main site of affected cervical IVDD accounted for 38.2% (34/89 cases) of the overall. The second to third cervical (C2-3) intervertebral disk space was affected most commonly, was described in. Fifteen dogs (44.1%) had acute onset of clinical signs and sixteen dogs (47.1%) had chronic onset of clinical signs. The most common clinical sign was tetraparesis in eleven dogs (32.4%). Grade 4 of neurologic status was presented in thirteen dogs (38.2%).

Thoracolumbar disk disease

The Main site of affected thoracolumbar IVDD accounted for 57.3% (51/89 cases) of the overall. The twelfth to thirteenth thoracic (T12-13) intervertebral disk space was affected most commonly was described in. Twenty-three dogs (45.1%) had chronic onset of clinical signs and twenty dogs (39.2%) had acute onset of clinical signs. The most common clinical sign was pelvic-limb paresis in forty-six dogs (90.2%). Grade 2 of neurologic status was presented in seventeen dogs (33.3%), mostly.

Table 3. The number of prognosis and recurrence in 89 IVDD patients

		Number	Percentage
Prognosis	Excellent	35	39.3
	Fair	1	1.1
	Poor	1	1.1
	Euthanized	3	3.4
	Sudden death	2	2.3
	No-follow up	47	52.8
	Total	89	100
Recurrence	Medication	7	16.7
	Surgery	6	14.3
	Total	13	40.0

Treatments and prognosis

Thirty-five dogs (39.3%) were managed successfully and three dogs (3.4%) were euthanized at the owner's request. Two dogs (2.3%) were suddenly death while performing MRI and forty-seven dogs (52.8%) were lost to follow up. Recurrence rate in follow-up patients was seen in thirteen dogs (40.0%). In this study, seven dogs (16.7%) had recurrence rate treated by medical treatment and six dogs (14.3%) had recurrence of clinical signs by surgical treatment (Table 3). Thirteen (40.7%) of thirty-two dogs were managed successfully with medical treatment. Total twenty-one dogs were managed by surgery, Cervical - IVDD were applied ventral slot and Thoracolumbar - IVDD almost applied hemilaminectomy, one case mixed partial lateral corpectomy and one case was performed mini-hemilaminectomy and partial lateral corpectomy to surgically decompress the spinal cord. Fifteen (71.4%) of twenty-one dogs were fully recovered by

Table 4. The compression rate and prognosis with IVDD treated by medication (n = 32) and surgery (n = 22)

Treatment	Compression rate	Excellent		Failure		No-follow up		Total	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Medication	Mild (1-25%)	5	31.3	3	18.8	8	50	16	100
	Moderate (26-50%)	5	45.5	0	0	6	60	11	100
	Severe (51-100%)	3	60	0	0	2	40	5	100
	Total	13	40.6	3	9.4	16	50	32	100
Surgery	Mild (1-25%)	2	66.7	0	0	1	33.3	3	100
	Moderate (26-50%)	3	50	1	16.7	2	33.3	6	100
	Severe (51-100%)	10	83.3	0	0	2	16.7	12	100
	Total	15	71.4	1	4.8	5	23.8	21	100

Table 5. The neurologic status and prognosis with IVDD treated by medication (n = 32) and surgery (n = 22)

Treatment	Neurologic status	Excellent		Failure		No-follow up		Total	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Medication	Grade 5	0	0	0	0	2	100	2	100
	Grade 4	6	42.9	1	7.1	7	50	14	100
	Grade 3	2	40	1	20	2	40	5	100
	Grade 2	3	42.9	1	14.3	3	42.9	7	100
	Grade 1	1	100	0	0	0	0	1	100
	Grade 0	0	0	0	0	0	0	0	0
	Neuropathy	1	33.3	0	0	2	66.7	3	100
	Total	13	40.6	3	9.4	16	50	32	100
Surgery	Grade 5	0	0	0	0	0	0	0	0
	Grade 4	2	66.7	0	0	1	33.3	3	100
	Grade 3	1	100	0	0	0	0	1	100
	Grade 2	7	70	0	0	3	30	10	100
	Grade 1	4	80	0	0	1	20	5	100
	Grade 0	1	50	1	50	0	0	2	100
	Total	15	72.7	1	45.5	5	22.7	21	100

surgery. Four dogs (50%) of eight dogs were managed by acupuncture successfully. Physical rehabilitation was combined with other treatment.

In this study, neurologic status was toward the grade 0 in grade 5 and compression rate was more severe, surgical treatment has been tried overall (Tables 4, 5). The excellent prognosis of surgical treatment dogs (71.4%) was higher than medical treatment dogs (40.6%). In the surgery group, excellent prognosis of dogs with compression rate of mild, moderate, and severe were 66.7%, 50% and 83.3%, respectively (Table 4). The surgical treatment was compared with medical treatment according to neurologic status and compression rate, there was a significant association with neurologic status and compression rate.

Discussion

Evaluation of our results necessitates consideration of the source and nature of the data. Therefore, the canine sample population in this report may differ from the general clinic population. It is thus necessary to consider the data in this report with careful attention to our sample population (12). In present study, Maltese had the highest frequency at twenty-two (24.4%) and had Pekingese nineteen (20%).

This breed distribution was different with previous studies, which was that the Dachshund had the highest frequency of IVDD within canine breed (10). This may be a result of relative breed popularity in each country. Some studies found that male dogs and neutered female dogs were at a higher risk than intact female dogs (15). Currently, MRI is considered the gold standard for diagnostic imaging in IVD disease, providing excellent tissue contrast resolution, images in multiple planes, and a lesion localization sensitivity of 100% (19).

In 1988, there was no mention of the disks extruding to the left or right. In cases where there is no lateralization of neurological signs or myelography, the surgeon performing lateral decompression risks choosing the wrong side on which to operate (4). In this study, location of disk material had the highest frequency at ventral region (69.9%).

The most common clinical sign of the dogs in present study was pelvic-limb paresis, which accounted for the most neurological sign of thoracolumbar IVDD, and tetraparesis, which accounted for the most neurological sign of cervical IVDD. Neurological signs were associated with affected sites. The active vertical mobility of spine is reflected in the structural design of the vertebral column. The vertebral column of the dog is very flexible in the dorsal direction and fairly mobile in the ventral direction. This mobility is especially large in the diaphragmatic region (i.e., thoracolumbar junction). Pivoting of the vertebral column at the diaphragmatic region provides a propulsive thrust to the hind limbs, which are drawn under the body during the gallop (6).

The inability of the IVD to fulfill its physiological function interferes with the normal action of the vertebral column, thereby influencing other components of the functional spinal unit, such as ligaments, facet joints, and vertebral bodies (1). Therefore, deficits in the biomechanical quality and integrity of the IVD caused by degeneration can lead to structural failure of the functional spinal unit and ultimately to spinal cord compression (2). In present study, most common compression main site were C2-3 (38.2%) at cervical region and T12-13 (37.2%) at thoracolumbar region, which agrees with other studies (8,11,14,21).

In present study, recurrence of applied surgery was C-IVDD 2 dogs (33.3%), TL-IVDD 4 dogs (23.5%), respectively. Nevertheless, with 6 dogs (40%) of 15 with suspected recurrence of pain during long-term follow-up, the disk material inadvertently left in place during ventral slot procedure might be considered a potential risk factor (5).

A previously published retrospective study (8) revealed a confirmed recurrence rate of 4.4% and an additional unconfirmed recurrence rate of 15.8% obtained via telephone follow-up in dogs with thoracolumbar intervertebral disk disease.

The rate for first-time recurrence was 12.7% (24/189). And suggested multiple-site disk fenestration decreased the rate of recurrent IVDD in small-breed dogs (7). However, statistical comparison between the single fenestration and prophylactic fenestration groups did not reveal a significant difference in the rate of recurrence (8). However, in this study, there was a limit in calculating the recurrence rate because the follow-up cases were 47.2% of the total patients. It is necessary to study various methods to obtain precise follow - up related to the symptoms of patient from the owners through further study.

A previously published retrospective study, despite the subjective belief of the surgeons having achieved complete spinal cord decompression at time of finishing surgery, a significant amount of dogs may still experience some degree of extradural SCC. Especially, residual extradural compression at the level of the affected disc may have to be expected in a significant number of cases. And propose that routine postoperative imaging of spinal decompression and endoscopically assisted ventral slot procedure might help to improve observation in the future (5).

A previous study, treatment options that severe neurological deficits with disk herniation were best managed by surgical intervention (13). In present study, the prognosis after surgical treatment group, dogs with compression rate with severe had highest excellent prognosis (83.3%).

Conclusion

This study is extensive descriptive study of IVDD. Studies have shown that the most represented species are Maltese and Pekingese.

The most common clinical symptoms were chronic onset, and the most common symptom was pelvic-limb paresis.

As a result of the MRI test, Hansen type II occupied the largest proportion.

In cervical region, the second to third cervical (C2-3) intervertebral disk space was affected most commonly and the twelfth to thirteenth thoracic (T12-13) intervertebral disk space was affected most commonly in thoracolumbar region.

The neurologic status and compression rate were significant different exist between medical or surgical treatment. The surgery is more effective than medical treatment for IVDD patients with severe neurological status and spinal cord compression.

Acknowledgement

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2017R1D1A3B03035592).

References

1. Adams MA, Roughley PJ. What is intervertebral disc degeneration, and what causes it?. Spine 2006; 31: 2151-2161.
2. Bergknut N, Smolders LA, Grinwis GC, Hagman R, Lagerstedt A-S, Hazewinkel HA, Tryfonidou MA, Meij BP. Intervertebral disc degeneration in the dog. Part 1: Anatomy and physiology of the intervertebral disc and characteristics of intervertebral disc degeneration. Vet J 2013; 195: 282-291.
3. Besalti O, Ozak A, Pekcan Z, Tong S, Eminaga S, Tacal T. The role of extruded disk material in thoracolumbar intervertebral disk disease: a retrospective study in 40 dogs. Can Vet J 2005; 46: 814.
4. Black A. Lateral spinal decompression in the dog: a review of 39 cases. J Small Anim Pract 1988; 29: 581-588.
5. Böttcher P, Böttcher IC, Truar K, Ludewig E, Oechtering G, Flegel T. Effect of ventral slot procedure on spinal cord compression in dogs with single static intervertebral disc disease: preliminary findings while evaluating a semiquantitative computed tomographic myelographic score of spinal cord compression. Vet Surg 2013; 42: 383-391.
6. Bray JP, Burbidge HM. The canine intervertebral disk: part one: structure and function. J Am Anim Hosp Assoc 1998; 34: 55-63.
7. Brisson BA, Holmberg DL, Parent J, Sears WC, Wick SE. Comparison of the effect of single-site and multiple-site disk fenestration on the rate of recurrence of thoracolumbar intervertebral disk herniation in dogs. J Am Vet Med Assoc 2011; 238: 1593-1600.
8. Brisson BA, Moffatt SL, Swayne SL, Parent JM. Recurrence of thoracolumbar intervertebral disk extrusion in chondrodystrophic dogs after surgical decompression with or without prophylactic fenestration: 265 cases (1995–1999). J Am Vet Med Assoc 2004; 224: 1808-1814.
9. Buttin P, Millet M, Cousin S, Carozzo C, Cachon T, Fau D, Chuzel T, Viguier E. Computed tomographic measurements with and without myelography to characterise thoracolumbar extruded disc herniation. J Small Anim Pract 2013; 54: 521-530.
10. Hoerlein BF. Canine neurology: diagnosis and treatment. Canine neurology: diagnosis and treatment. 1965.
11. Huska J. Comparison of Hemilaminectomy and Mini-hemilaminectomy in Dogs with Thoracolumbar Intervertebral Disc Extrusion Using Computed Tomography and Magnetic Resonance Imaging: An Anatomical and Radiological Study. 2013.
12. Itoh H, Hara Y, Yoshimi N, Harada Y, Nezu Y, Yogo T, Ochi H, Hasegawa D, Orima H, Tagawa M. A retrospective study of intervertebral disc herniation in dogs in Japan: 297 cases. J Vet Med Sci 2008; 70: 701-706.
13. Levine JM, Levine GJ, Johnson SI, Kerwin SC, Hettlich BF, Fosgate GT. Evaluation of the success of medical management for presumptive thoracolumbar intervertebral disk herniation in dogs. Vet Surg 2007; 36: 482-491.
14. Mayhew PD, McLear RC, Ziemer LS, Culp WT, Russell KN, Shofer FS, Kapatkin AS, Smith GK. Risk factors for recurrence of clinical signs associated with thoracolumbar intervertebral disk herniation in dogs: 229 cases (1994-2000). J Am Vet Med Assoc 2004; 225: 1231-1236.
15. Priester WA. Canine intervertebral disc disease - occurrence by age, breed, and sex among 8,117 cases. Theriogenology 1976; 6: 293-303.
16. Ruddle TL, Allen D, Schertel E, Barnhart M, Wilson E, Lineberger J, Klocke N, Lehenbauer T. Outcome and prognostic factors in nonambulatory Hansen type I intervertebral disc extrusions: 308 cases. Vet Comp Orthop Traumatol 2006; 19: 29-34.
17. Sether LA, Nguyen C, Yu S, Haughton VM, Ho K, Biller D, Strandt J, Eurell J. Canine intervertebral disks: correlation

of anatomy and MR imaging. Radiology 1990; 175: 207-211.
18. Sharp N, Wheeler S. Small Animal Spinal Disorders: Diagnosis and Surgery, 2nd ed. 2005.
19. Tidwell AS. Advanced imaging concepts: a pictorial glossary of CT and MRI technology. Clin Tech Small Anim Pract 1999; 14: 65-111.
20. Tobias KM, Johnston SA. Veterinary Surgery: Small Animal-E-BOOK: 2-Volume Set. Elsevier Health Sciences. 2013
21. Verheijen J, Bouw J. Canine intervertebral disc disease: a review of etiologic and predisposing factors. Vet Q 1982; 4: 125-134.