Original article

Imaging of Thoracic and Lumbar Intervertebral Disc Herniation Cases with MRI: A Retrospective Study

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Abstract. *Study Objectives:* The objective of this study was to make a comparison between the results of the neurological examination performed due to suspected IVDD (Intervertebral Disk Degeneration) and thoracolumbar spinal cord trauma and the findings of MRI (Magnetic Resonance Imaging) of 26 dogs and four cats that were referred to the center with such complaints as paraplegia, paralysis, incoordination, and urine incontinence/retention. *Methods:* A neurological examination involving quadriceps (patellar) reflex, flexor pedal reflex, panniculus reflex, and anal reflex was performed on a total of 30 patients (26 dogs and 4 cats), their radiographs were taken, and an MRI procedure was applied under anesthesia. *Results:* MRIs of the cases that were referred to Pamuk Veterinary Therapy Center between March 2018 and May 2021 were taken in transverse, coronal (dorsal), and sagittal planes as T1-weighted (T1W), T2-weighted (T2W). It was figured out that, in 65.4 percent of the dogs the discs between L1 and L7 were exposed to a greater impact compared to other regions, while the rate was 75 percent for cats. All cases were diagnosed with disc degeneration; accordingly, eight of the dogs had Type I, nine Type II, and nine Type III, while two cats had Type I, one Type II, and one Type III. For dogs, a significant correlation was found between body weight, PR, and IVDS; however, no significant correlation was observed between PR, IVDS (Intervertebral Disc Space), and species, breed, gender, or age. *Conclusion:* Based on the results of this study it can be argued that the findings obtained through panniculus reflex examination performed on lesional thoracic and lumbar disc regions can be used in combination with MRI, providing a clinically acceptable consistency rate.

Key words: Intervertebral disc, thoracolumbar disc, magnetic resonance imaging, spinal cord

Introduction

Considering that there are a limited number of diagnostic tests that provide useful information about the structural integrity and pathological characteristics of the nervous system, it can be challenging to diagnose central nervous system (CNS) abnormalities in dogs. Anatomical imaging procedures such as MRI, on the other hand, make it easier to diagnose structural nervous system abnormalities (1). Accordingly, various MRI properties and screening sequences are used to investigate tumors associated with the spine, spinal cord, and vertebral canal of dogs (2).

Today, Magnetic Resonance Imaging (MRI) machines are available in most veterinary medicine education hospitals and private centers (3), where they are commonly used to examine dogs with thoracolumbar myelopathy (4). MRI's diagnostic potential is commonly used in veterinary medicine to view animals' spines and spinal cord (2). In some cases, such as intervertebral disc extrusion, there is no proper method to assess the prognosis, which turns informing pet owners preoperatively about the possible benefits of a surgical intervention into a challenging task. MRI can be effectively used to investigate spinal cord injuries, formulate prognosis, and diagnose spinal cord edema, bleeding, and swelling (5, 6). Furthermore, it is commonly used to diagnose brain lesions, and brain tumors in particular, in small animals (7).

MRI is an excellent imaging method that has a significant potential to visualize soft tissues and it has improved our ability to investigate the anatomy of and pathological changes in the brain and spinal cord from an in vivo perspective (8). MRI, or Magnetic Resonance Imaging, provides clear images of the soft tissues on the spine, and helps recognize pathological changes accurately (9, 10, 11). IVDD (Intervertebral Disc Disease) is a very common term used in veterinary medicine, and it involves a series of lesions affecting the intervertebral disk. IVDD in dogs was first diagnosed by Dexler in the late 1800s (12, 13), then steps have been taken to understand underlying etiological factors, which led to a gradual evolution in terminology and classification systems.

Initial reports described the presence of cartilaginous material in the epidural space of the vertebral canal, also known as enchondrosis intervertebral, which was later associated with degenerated nucleus pulposus (12, 13). Building on these findings in the 1940s and 1950s, Hansen and Olsson made great progress in understanding the nature of canine IVDD and proposed a classification system based on histopathological degenerative changes that are still in use today (13, 14, 15). Accordingly, they defined two different IVD degeneration types, i.e. chondroid and fibroid metaplasia, associated with specific breeds and races, as a result of which canine races began to be classified as chondrodystrophic (chondroid metaplasia) and non-chondrodystrophic (fibroid metaplasia) according to prevailing IVDD type (16, 17). Furthermore, thanks to their studies, IVDD was later classified as Hansen Type I and Hansen Type II herniations, which is still a popular system used in veterinary medicine (14, 16, 18). Several interchangeable terms are used to define IVD material's shift in the vertebral canal, including "protrusion", "extrusion", "prolapsus" and "herniation" (13, 15). As a matter of fact, in 1951, Olsson stated that "disc protrusion is synonymous with disc herniation and disc prolapsus" (13). Since then, the term "IVD extrusion" has become more frequently linked with the acute extrusion of nucleus pulposus from an IVD with chondroid metaplasia-like traits, whereas "IVD protrusion" has largely been used for chronic annulus fibrosus thickening originally associated with fibroid metaplasia. On the other hand, the term "IVD herniation" is still largely used as an umbrella term that does not refer to a specific type of degenerative change. The improved diagnostic ability has led to the increasingly frequent diagnosis of IVD conditions, including the herniation of relatively well-hydrated nucleus pulposus material (19, 20). Accordingly, the condition called Hansen Type III IVD herniation has recently been accepted as acute non-compressive nucleus pulposus extrusion (ANNPE) (19, 21, 22). While all these terms refer to describe a non-compressive peracute extrusion of the nucleus pulposus, they also apply to cases of compressive extrusion of degenerative nucleus pulposus following vertebral column trauma (23).

Recently, more progress has been made in understanding IVDD, and the use of detailed histological grading systems has suggested that both chondrodystrophic and non-chondrodystrophic breeds of dogs undergo chondroid metaplasia, albeit at very different rates and times (18, 24, 25). In addition to these advances in histological and genetic descriptions of IVDD, advances in diagnostic techniques such as magnetic resonance imaging (MRI) are accepted as the gold standard for imaging canine and feline IVDD types, providing excellent tissue contrast resolution, multiplane images, and 100% lesion localization sensitivity (26).

The objective of this study was to investigate pre-MRI neurological examination and reflex test (lesional IVDD region was planned to be detected on MRI based on panniculus reflex) results, and post-MRI thoracic and lumbar intervertebral disc herniation data about cats and dogs with IVDD and spinal cord trauma, which varied in terms of breed, age, gender, and body weight.

Materials and Methods

Case Selection

Neurological examination involving quadriceps (patellar) reflex, flexor pedal reflex, panniculus reflex, and anal reflex was performed on a total of 30 patients

(26 dogs and four cats) that were referred to Pamuk Veterinary Therapy Center located in Izmir/Turkey between March 2018 and May 2021 with such complaints as paraplegia, paralysis, incoordination, and urine incontinence/retention, and patient records were created.

Procedures

Details of each case, including their age, gender, breed, body weight, and glucocorticoid administration status, were recorded in a log. The dogs were classified as chondrodystrophic (Dachshund, French Bulldog, and Pekingese) and non-chondrodystrophic (Doberman, Golden Retriever, Rottweiler, and mix).

Neurological Status

It was assumed that flexor pedal reflex was intact in dogs who reacted by voice or bites when their hind toes were clamped with surgical forceps.

During quadriceps (patellar) reflex examination, on the other hand, reflexes were graded, where no reflex meant 0 point, while depressed reflex, normal reflex, exaggerated reflex, and exaggerated reflex with clonus referred to +1, +2, +3, +4 points, respectively. The Hind legs' flexor reflex is associated with spinal cord vertebrae (L6-S1) and sciatic nerve. Thus, no (0) and depressed (+1) reflex indicate a lesion on these vertebrae or nerves. Accordingly, the absence of reflex on one side means a peripheral nerve lesion, while no or depressed reflex on both sides indicates a possible spinal cord lesion. A normal (+2) flexor reflex, on the other hand, indicates that vertebrae and nerves are functional, while increased (+3) flexor reflex is evidence of acute lesions on descending pathways. And finally, an exaggerated reflex (+4) refers to constant flexion of both hind legs, which usually indicates a chronic problem rather than the severity of the lesion. During the perineal (anal) reflex examination, the perineum is gently stimulated using forceps, where a painful stimulus is usually not necessary. Anal sphincter muscle and tail contract as a response. No or depressed reflex means sacral nerve spinal cord lesion or pudendal nerve lesion (27, 28, 29). Cutaneous trunci reflex (panniculus reflex) examination is based on the contraction of cutaneous trunci muscle, during which the skin is pinched between T2 and L6-7 or pricked. The reflex arc includes the afferent cutaneous branches of the lumbar and thoracic spinal nerves, C8 to T1 spinal cord segments, and LMNs (Lower Motor Neuron Lesion) in the lateral thoracic nerve innervating the cutaneous trunci muscles. A focal spinal cord lesion that interrupts this pathway results in loss of the reflex caudal to the level of the lesion (27, 29, 30, 31).

Radiography

Ventro-dorsal (V/D) and latero-lateral (L/L) bidirectional images were obtained using an X-Ray.

Anesthesia

For MRI, the dogs were administered diazepam (0.2 mg/kg [0.09 mg/lb], IV) and propofol (5 mg/kg [2.3 mg/lb], IV); and the anesthesia was maintained with a fixed rate propofol infusion (0.3 to 0.4 mg/kg/min [0.14 to 0.18 mg/lb/min], IV).

Imaging Data

1.5 Tesla surface coil MRIs were produced for all cases referring to Pamuk Veterinary Therapy Center.

Sagittal T1-weighted images were produced with a repetition time of 400 to 700 milliseconds and an echo time of 10 to 14 milliseconds, while sagittal T2-weighted images were produced with a repetition time of 3,000 to 4,000 milliseconds, and an echo time of 90 to 99 milliseconds.

Transverse T1-weighted images, on the other hand, were produced with a repetition time of 370 to 700 milliseconds, and an echo time of 12 to 20 milliseconds, while transverse T2-weighted images were produced with a repetition time of 2,000 to 4,000 milliseconds, and an echo time of 90 to 98 milliseconds. In transverse images, slice thickness was 2 mm, and the gap between slices was 0 mm. Based on the size of the dog, two to four slices were produced for each disc. Both dogs and cats were specifically classified in accordance with the Hansen typology (Type I, Type II, and Type III).

To accept that the MRI appearance of the intervertebral disc is normal, there must be a clear distinction between the CSF (cerebrospinal fluid) signal intensity and the hyperintense/isointense signal intensity of the annulus fibrosus and nucleus pulposus, and the nucleus pulposus must be homogeneous and bright white. In type I disc degeneration, the nucleus pulposus is structurally inhomogeneous (with or without vertical bands in the center of the disc). However, when compared with the signal intensity of CSF, there is a clear distinction between the hyperintense/isointense signal intensity of the annulus fibrosus and the nucleus pulposus. In type II disc degeneration, the intervertebral disc space is inhomogeneous or gray, the distinction between annulus fibrosus and nucleus pulposus is unclear, and the signal intensity is moderate. In type III disc degeneration, on the other hand, the intervertebral disc space is structurally inhomogeneous and gray to black, the distinction between the annulus fibrosus and nucleus pulposus is lost, the signal intensity is moderate to hypointense, and the disc space width is reduced (32).

Conditions with the circumferentially symmetrical uniform extension of the outer margin of the disc were considered disc bulge, and cases where the disc protrudes in a central direction or to the right or left with focal distortion of the ring were considered disc protrusion. However, dogs were classified as having disc extrusion if the disc herniated through all layers of the annulus and presented as a focal epidural mass. Disc extrusion was observed in two ways, depending on whether the annulus pulposus of the intervertebral disc lost its integrity and whether the nucleus pulposus was dispersed in the epidural space. While characterizing and diagnosing the lesions, the place of origin, anatomical location, signal characteristics in T1W and T2W images, shape/size, IVDD count, and presence of swelling were evaluated.

Statistical Analysis

The study data were analyzed using the SPSS 21.0 for Windows package program. The variables in the study were manifested through descriptive statistics (n, %, mean, SD). Furthermore, Chi-Square test was applied in intervariable relations. The statistical significance level was accepted as 0.05. Finally, an Independent Samples t-test was used to compare body weight according to IVDS and PR.

Results

All patients were between 2 and 8 years of age, while their body weights varied between 3.5 and 6.2 kilograms. Of the 12 female and 14 male dogs, four were Dachshund, while the numbers of other breeds, i.e., French Bulldog, Golden Retriever, Rottweiler, Doberman, Pekingese, and mix, were five, four, two, three, five, and three, respectively. Of all dogs, 15 (57.7%) were chondrodystrophic. A total of four cats (three female and one male; two Domestic Shorthair (DSH) and two Persian) were involved in the study. MRI findings indicated that all 26 dogs had disc degeneration (eight Type I, nine Type II, nine Type III), five had intervertebral disc bulging, nine had disc protrusion, and 11 had disc extrusion (eight dispersed and three non-dispersed) (Table 1). It was found out that the L1-L7 region was affected in 65.4 percent of the dogs. Two cats, on the other hand, had Type I disc degeneration, while Type II and Type III disc degeneration affected one cat each. Accordingly, two cats had intervertebral disc bulging, one had disc protrusion, and one had dispersed disc extrusion. It was further found out that the L1-L7 region was affected in 75 percent of the cats (Table 1).

Table 2 presents the results of Chi-squared test, which was performed to compare IVDS regions determined based on panniculus reflex examination and MRI. Accordingly, 100 percent of the findings obtained through PR examination verified MRI findings for the L1-L7 region, while 90 percent verified MRI findings for the T1-T13 region.

In dogs, a significant correlation was found between body weight, PR and IVDS ($p<0.05$) (Table 3). According to the findings, body weight showed a significant difference in terms of PR and IVDS. A review of the mean values indicated that mean body weight was 24.27 for T1-T13, and 12.36 for L1-L7. In terms of the PR, the body weight was observed to be 22.70 for T1-T13, and 13.31 for L1-L7. Cats, on the other hand, provided no such finding, and no significant relationship was observed between PR/IVDS (Intervertebral Disc Space) and species, breed, gender, or age ($p>0.05$).

Table 1. Feline and Canine Variable Table

Variables	Groups	Cat n (%)	Dog n (%)
Species		4 (13.3)	26 (86.7)
Breed	DSH	2 (50.0)	-
	Persian	2 (50.0)	-
	Golden Retriever	-	4 (15.4)
	Daschund	-	4 (15.4)
	Rottweiler	-	2 (7.7)
	French Bulldog	-	5 (19.2)
	Doberman	-	3 (11.5)
	Pekingese	-	5 (19.2)
	Mix	-	3 (11.5)
Gender	Female	3 (75.0)	12 (46.2)
	Male	1 (25.0)	14 (53.8)
IVD degeneration type	Chondrodystrophy	-	15 (57.7)
	Non-chondrodystrophy	-	11 (42.3)
Glucocorticoids administration	Administered	3 (75.0)	19 (73.1)
	Not administered	1 (25.0)	7 (26.9)
Cause of trauma	Fall from height	2 (50.0)	-
	Unknown	1 (25.0)	19 (73.1)
	Traffic accident	1 (25.0)	2 (7.7)
	Sudden, unexpected	4 (15.4)	-
	Fight	1 (3.8)	-
Quadriceps (patellar) reflex (QPR)	Hyperreflexia	1 (25.0)	4 (15.4)
	Normal	2 (50.0)	9 (34.6)
	Decreased	1 (25.0)	6 (23.1)
	Absent	-	7 (26.9)
Degree of QPR	0	-	7 (26.9)
	+1	1 (25.0)	6 (23.1)
	+2	2 (50.0)	9 (34.6)
	+3	1 (25.0)	4 (15.4)
Flexor pedal reflex (FPR)	Present	3 (75.0)	16 (61.5)
	Absent	1 (25.0)	10 (38.5)
Degree of FPR	0	1 (25.0)	9 (34.6)
	+1	2 (50.0)	5 (19.2)
	+2	-	4 (15.4)
	+3	-	5 (19.2)
	+4	1 (25.0)	3 (11.5)
Anal Reflex	Present	4 (100.0)	16 (61.5)
	Absent	-	10 (38.5)
Urine Incontinence/Retension	Present	3 (75.0)	9 (34.6)
	Absent	1 (25.0)	17 (65.4)

(*Continued*)

Variables	Groups		Cat n (%)	Dog n (%)
Incoordination	Both hind legs		1 (25.0)	8 (30.8)
	Left hind leg		2 (50.0)	3 (11.5)
	Paraplegia		1 (25.0)	10 (38.5)
	Right hind leg		-	5 (19.2)
Disc protrusion (DP)	Present		1 (25.0)	9 (34.6)
	Absent		3 (75.0)	17 (65.4)
Bulging	Present		2 (50.0)	5 (19.2)
	Absent		2 (50.0)	21 (80.8)
Disc extrusion	Dispersed-central		1 (25.0)	4 (15.4)
	Dispersed-right		-	2 (7.7)
	Dispersed-left		-	2 (7.7)
	Absent		3 (75.0)	18 (69.2)
	Non-dispersed-central		-	1 (3.8)
	Non-dispersed-right		-	2 (7.7)
	Non-dispersed-left		-	-
	Absent		4 (100.0)	23 (88.5)
Disc degeneration	Type I		2 (50.0)	8 (30.8)
	Type II		1 (25.0)	9 (34.6)
	Type III		1 (25.0)	9 (34.6)
Panniculus reflex (PR)	L1-L7		3 (75.0)	17.9 (65.4)
	T1-T13		1 (25.0)	9 (34.6)
Intervertebral disc space (IVDS)	L1-L7		3 (75.0)	18 (69.2)
	T1-T13		1 (25.0)	8 (30.8)
	Min.	Max.	Mean±SD	Mean±SD
Age	2	8	5.00±2.94	7.58±3.02
Body weight (BW)	3.5	6.2	4.87±1.28	16.56±12.00

Table 2. Comparison between the Results of Panniculus Reflex Examination and MRI

Variables			IVDS		χ^2	P
			L1-L7	T1-T13		
PR	L1-L7	n (%)	20 (100.0)	0 (0.0)	25.714	0.000*
	T1-T13	n (%)	1 (10.0)	9 (90.9)		

*p<0.01

Discussion and Conclusion

In this study we proved that panniculus reflex is a significant neurological examination method in IVDD, providing significant information about which regions needed to be scanned with an MRI device. IVDD was reported to be more common in Maltese Terrier (24.4%), Pekingese (20%) breeds (26). Furthermore, it was argued that male and sterilized female dogs were at higher risk (33). In the present study, it was defined four types of IVDD based on MRI findings, namely disc degeneration, intervertebral disc bulging, disc

Table 3. Comparison of Body Weight, Based on IVDS and PR

Variables	IVDS	Mean	SD	P
IVDA	L1-L7	12.36	8.24	0.025*
	T1-T13	24.27	15.60	
PR	L1-L7	13.31	8.66	0.046*
	T1-T13	22.70	15.33	

*$p<0.05$

protrusion and disc extrusion, and found no correlation between lesional IVD region and species, breed, gender, or age.

Since there was no retrospective patient record, the disease was at chronic period (glucocorticosteroid administration), and pet owners did not care, the study found no indication of whether disc degeneration was a preparatory factor for extrusion. There also was uncertainty about whether bulging and protrusion would lead to extrusion. In these cases, operation is required since waiting may cause ischemia in the spinal cord. For dogs, the most common neurological clinic symptom of thoracolumbar IVDD was reported to be pelvic-limb paresis (26). Similarly in the present study the most common symptom was detected to be paraplegia (38.5%).

Failure of IVD to perform its physiological function interferes with the normal movement of the vertebral column, thereby affecting the functional spinal unit, articular surfaces, and other components such as vertebral bodies (34). Therefore, deficiencies in the biomechanical quality and integrity of IVD caused by degeneration can lead to structural dysfunction of the functional spinal unit and ultimately to spinal cord compression (24). In various studies, thoracolumbar region T12-13 was found to be the most common main compression area (37.2%) (35, 36, 37). In the present study, L1-L7 and T1-T13 disc spaces were found to be affected to a greater extent compared to the other areas. Decreased signal intensity, evident on T2-weighted images of degenerative discs, is associated with progressive degenerative changes in the disc (38). Diagnosis and treatment principles are similar in dogs and cats with suspected disc protrusion (39). If there is radiographic evidence of significant extradural compression, surgery is indicated to remove extruded disc material from the vertebral canal (40). However, a small amount of extruded disc material may be dispersed in the epidural fat, which may be difficult to detect surgically (41). Furthermore, it was reported that surgery may be less beneficial if there is very little disc material in the vertebral canal or if extruded disc material perforates the dura and enters the spinal cord (42).

The results obtained from the present study indicated that IVDD can develop in one or more regions in dogs, and that MRI and neurological examination (panniculus reflex) should be used together to detect the location of the lesion and the disc range causing clinic symptoms. According to the findings of the study, disc degeneration, intervertebral disc bulging, and disc protrusion are associated with clinical symptoms.

Intervertebral disc bulging is anatomically different from disc protrusion and degeneration. A bulged disc extends to the vertebral canal diffusely. In contrast, the protrusion represents a shift in the position of the nucleus pulposus secondary to the rupture of the innermost annular fibers at a single point in one direction. Therefore, elongation of the disc in one direction was considered as a protrusion. The present study detected two types of extrusion, namely dispersed and non-dispersed.

In a study evaluating the magnetic resonance (MR) images of 11 dogs with traumatic disc extrusion, a decrease was detected in the volume and signal intensity of nucleus pulposus, together with focal hyperintensity in the spinal cord, as well as fine spinal cord compression in the spinal canal, foreign matter or signal change. The largest area of hyperintensity in the spinal cord was found to be directly above or near the afflicted disc space, with an asymmetrical appearance; also, the vacuum phenomenon, evident as a signal gap in the middle of the disc, was observed in 2 of the dogs. (43). According to the findings of the present study, dispersed and non-dispersed disc extrusion was most commonly observed at the center (15.4%) and on the left (7.7%), respectively, in dogs, while in cats non-dispersed disc extrusion was most commonly at the center (25%). The dogs involved in the study had various levels of paraplegia, which was thought to be caused by disc extrusion, disc protrusion, intervertebral disc bulking, and disc degeneration. The cases in the present study were mostly investigated during the chronic phase of the spinal cord injury, and the changes observed in the spinal cord signal intensity were generally compatible with the clinical findings. Furthermore, the degree of vertebral canal attenuation was found to be significantly in correlation with neurological status.

As a general rule, Type 1 disc degeneration is observed in small breed chondrodystrophic dogs, especially in Dachshund, Labrador Retriever, Doberman Pinschers, and Chow Chows. Type 2 degeneration, on the other hand, is typically observed in larger non-chondrodystrophic breeds such as German Shephard and Doberman Pinschers, while it is also common in small breeds such as Chihuahua, Yorkshire Terrier, and Malta Terrier (44). In the present study, Type 1 disc degeneration was detected in two Golden Retrievers (50%), one Daschund (25%), two French Bulldogs (40%), one Doberman (33%) and one Pekingese (20%); Type 2 in two Daschunds (50%), one Golden Retriever (25%), two French Bulldogs (40%), one Doberman (33%), one Rottweiler (50%), and two Pekingese (40%); and Type 3 in one Daschund (25%), one Rottweiler (50%), one French Bulldog (20%), two Golden Retrievers (50%), one Doberman (33%), two Pekingese (40%).

The findings indicate that PR results can be used to forecast MRI results of dogs with paraplegia caused by thoracolumbar intervertebral disc extrusion.

Traumatic spinal injuries, vertebra fractures, subluxations, or dislocations caused by car accidents, falls, fights and firearms may lead to a rupture in spinal cord dura or IVD (intervertebral disc) hernia. These injuries mostly result in spinal cord concussion, rupture, and compression (45). The cause of trauma was unknown for 19 dogs (73.1%) and one cat (25%) in the present study, while it was determined that two dogs (7.7%) and one cat (25%) started showing clinical symptoms after a car accident, while the cause of trauma was fall from height in two feline cases (50%).

The magnetic resonance imaging technique is very successful in locating spinal cord compression and distinguishing disc extrusion from protrusion. Increasing the number of MRI-diagnosed cases will help detect IVDD and enlighten underlying pathophysiology. Increased MRI use has made it possible to diagnose traumatic IVDD more accurately. According to the results obtained from the present study, lesional IVDS regions defined based on neurological status and MRI results were significantly similar. Furthermore, body weight was found to be a significant factor in PR and IVDS.

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