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Original article

Pathological findings in low-field magnetic resonance imaging of the canine spine – a study of 112 patients

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Abstract

Magnetic resonance imaging (MRI) is a method of choice in diagnosing nervous system disorders. This paper presents the results of a study where selected segments of the canine spine were examined by low-field MRI in 112 patients. Images of pathological changes were obtained in spin echo (SE), fast spin echo (FSE) and hybrid contrast enhancement (3D HYCE) sequences. The cervical region of the spinal cord (C1-C5) was examined in 32 patients, the cervicothoracic region (C6-Th2)- in 14 patients, the thoracolumbar region (Th3-L3) – in 23 patients, and the lumbosacral region (L4-S3) – in 43 patients. The results were used to determine the incidence of pathological changes in different sections of the canine spine, such as intervertebral disc disease (IDD), disc desiccation, syringomyelia and changes characterized by higher uptake of the contrast medium. Intervertebral disc disease was diagnosed in 52.7% of patients and it was the most common abnormality. Disc dehydration without protrusion or extrusion was noted in 23.2% of animals. Pathological changes with increased uptake of the contrast medium and indicative of neoplastic growth were observed in 13.4% of patients and syringomyelia was diagnosed in 9.82% of the examined animals. The proposed sequences revealed the presence of above abnormalities.

Key words: dogs, spine, magnetic resonance diagnostic

Introduction

Magnetic resonance imaging, the golden standard in diagnosing pathological changes in the spine, supports 3D visualization, diagnosis of epidural and intradural diseases and earlier detection of changes than in conventional radiography (Carrera et al. 2011). The changes visible in radiographic images, such as narrowing of the space between intervertebral

discs and joints, intervertebral foramen narrowing or mineralization, facilitate a correct diagnosis (Penning et al. 2006), but most pathological changes that accompany spinal diseases and injuries are not detected by conventional radiography. Myelography is widely used to evaluate the extent of spinal cord compression, edema and lateralization of intervertebral discs (Penning et al. 2006), but the main disadvantage of this method is that it is relatively invasive (Hecht et al.

Table 1.

Spinal region	Cervical region (C1-C5)	Cervicothoracic region (C6-Th3)	Thoracolumbar region (Th4-L3)	Lumbosacral region (L4-S3)	Total
Number of patients examined	32	14	23	43	112
Number of patients with IDD	23	–	19	17	59
Number of patients with changes in one disc	13	–	10	14	37
Number of patients with changes in multiple discs	10	–	9	3	22
Number of patients with disc desiccation	3	4	9	10	26
Number of patients with changes absorbing contrast agent	–	5	3	7	15
Number of patients with syringomyelia	11	–	–	–	11

2009). Magnetic resonance imaging supports the acquisition of images that are similar to myelographic images because it provides good contrast between the hyperintense cerebrospinal fluid signal in T2-weighted sequences and the hypointense subarachnoid space (Robertson and Thrall 2011). The causes of increased pressure on the spinal cord and its internal structure cannot be evaluated by myelography (Levitski et al. 1999). Magnetic resonance imaging visualizes the degree of compression on the spinal cord and the localization of displaced intervertebral discs, which significantly influences the choice of treatment and the postoperative prognosis. This study compares the effectiveness of selected MRI sequences in diagnosing pathological changes in the spinal cord of canine patients admitted to the veterinary clinic.

Materials and Methods

The study was performed on canine patients admitted for treatment to the Department of Surgery and Rentgenology between May 2010 and November 2015. A total of 112 dogs were examined, including 8 Yorkshire Terriers, 16 German Shepherds, 1 Welsh Corgi, 2 Miniature Pinschers, 1 Bolognese, 5 Giant Schnauzers, 12 Labrador Retrievers, 12 Cavalier King Charles Spaniels, 8 French Bulldogs, 2 Great Danes, 2 Boxers, 8 Dachshunds, 1 Rottweiler, 3 Doberman Pinschers, 2 Bernese Mountain Dogs, 1 Chihuahua, 1 Bavarian Mountain Hound, 1 Pug, 1 Slovakian Hound, 3 Border Collies, 2 Cane Corsos, 1 Shih Tzu, 1 Poodle and 18 mixed-breed dogs. The patients were admitted for MRI due to gait abnormalities, postural defects, defective exteroceptive and interoceptive sensation, hyperactive and hypoactive spinal cord reflexes confirmed in neurological examinations. Based on the

results of 2 neurological tests, the observed changes were classified as intracranial or extracranial, and if abnormal spinal cord reflexes were diagnosed, pathological changes were localized in the cervical region (C1-C5), cervicothoracic region (C6-Th2), thoracolumbar region (Th3-L3) and lumbosacral region (L4-S3). The cervical region of the spinal cord was examined in 32 patients, the cervicothoracic region – in 14 patients, the thoracolumbar region – in 23 patients, and the lumbosacral region – in 43 patients. Magnetic resonance imaging scans were performed under general anesthesia induced by intravenous injection of propofol at 5-6 mg/kg (Scanofol 10 mg/ml), followed by intramuscular injection of atropine at 0.05 mg/kg (Atropinum Sulfuricum 1mg/ml) and medetomidine 0.01-0.08 mg/kg. (Cepetor 1 mg/ml). The patients were subjected to MRI in a low-field MR scanner (Vet Grande Esaote I, 0.25 T). The cervical region was examined with the use of a knee coil (No. 2), and patients were placed in sternal recumbency with the evaluated segment positioned centrally in the coil. The remaining segments of the spine were examined with the use of the shoulder coil (No. 1), and patients were positioned on the left side with the evaluated segment directly adjacent to the coil. The exam began with the scout sequence, followed by the localizer sequence in sagittal, transverse and dorsal planes. Scout and localizer sequences are not used for diagnostic purposes, and they are applied to position the patient correctly, select the examined region and provide reference data for positioning individual slices. The MRI protocol consisted of T1- and T2-weighted FSE, SE and 3D HYCE sequences in transverse and sagittal planes. In the sagittal plane, slice thickness was 3-4 mm with a 0.3-0.4 mm gap, and in the transverse plane, slice thickness was 3-5 mm with a 0.2-0.3 mm gap, subject to the patient's size.

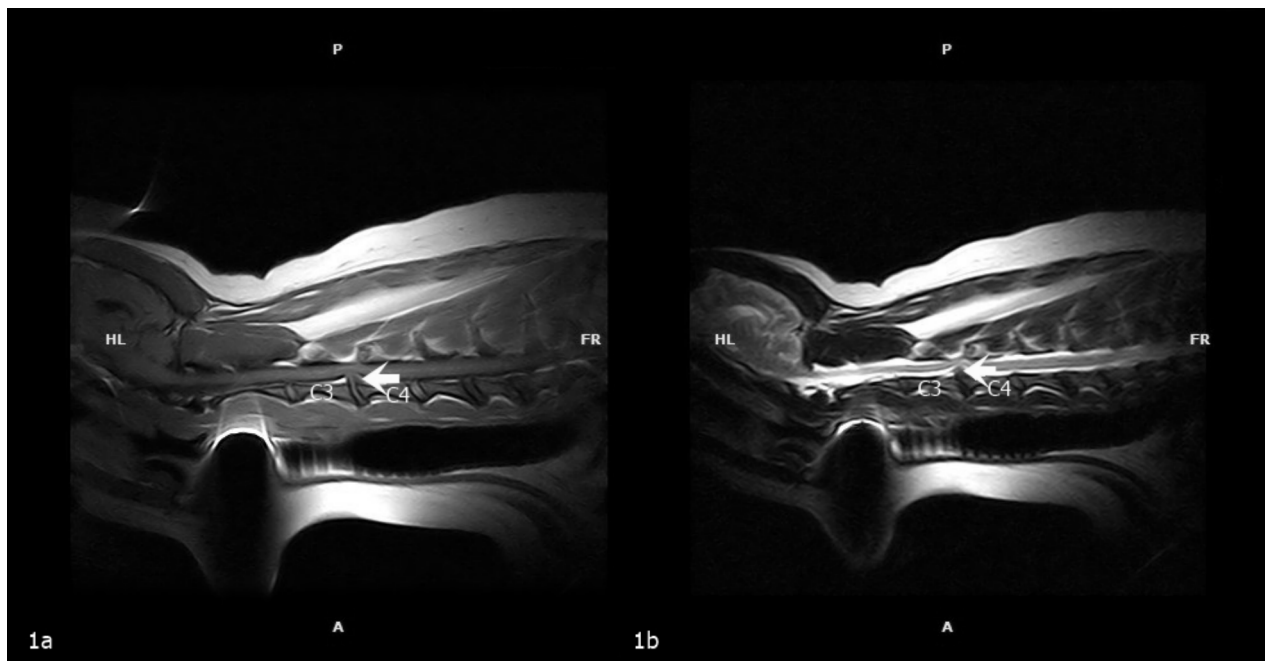


Fig. 1. a – T1 – weighted Spin Echo sequence image in sagittal plane, b – T2-weighted Fast Spin Echo sequence image in sagittal plane – MRI images showing disc protrusion (arrow) at the level of the C3-C4 vertebrae.

The contrast medium was gadolinium (Omniscan) administered intravenously at 0.2 mmol/kg BW.

Results

The most common pathological changes diagnosed by low-field MRI in 112 clinical patients were intervertebral disc disease (IDD), disc dehydration, changes characterized by higher uptake of the contrast medium and syringomyelia (Table 1). Intervertebral disc disease was diagnosed in 52.7% of patients. Degenerative changes in the cervical segment were noted in 71.9% of cases. In this group, multiple changes affecting at least two intervertebral discs were observed in 10 animals. Pathological changes were most frequently diagnosed in the C2-C3 intervertebral disc space (15 out of 23 dogs). Changes indicative of IDD were not noted in the cervicothoracic region. In the thoracolumbar region, changes indicative of IDD were observed in 82.6% of dogs, and most of them were localized in the Th13-L1 intervertebral disc space (13 out of 23 dogs). In 47% of patients, at least two intervertebral discs in the thoracolumbar region were affected by the above changes. In the lumbosacral region, changes were observed in 39.5% of dogs, and most of them were localized in the L7-S1 segment (16 out of 17 dogs). In three cases, pathological changes were noted in two intervertebral disc spaces. Disc dehydration without protrusion or extrusion was noted in 23.2% of animals. Those changes were localized in the cervical region in 9.3% of dogs, in the cervicothoracic region – in 28.6% of dogs, in the tho-

racolumbar region – in 39.1% of dogs, and in the lumbosacral region – in 23.2% dogs. Pathological changes with increased uptake of the contrast medium and indicative of neoplastic growth were observed in 13.4% of patients. Syringomyelia was diagnosed in 9.82% of the examined animals.

Discussion

Magnetic resonance imaging is an excellent diagnostic tool for evaluating all segments of the spine. It visualizes the structure of vertebrae, intervertebral discs and spinal nerve roots (Levitski et al. 1999). The acquired images were mapped onto the grey-scale. The adipose tissue was the brightest tissue with the highest signal intensity in both T1- and T2-weighted sequences. The structure of the cancellous bone, nucleus pulposus, spinal cord, muscles, cerebrospinal fluid, fibrous rings and ligaments was evaluated in T1-weighted sequences, from the brightest to the darkest tissues. In T2-weighted sequences, the brightest objects were the adipose tissue, followed by cerebrospinal fluid and healthy nuclei pulposi (Levitski et al. 1999). In the 3D Hyce sequence, cerebrospinal fluid was characterized by the highest signal intensity, followed by homogeneous weaker signals in soft tissues and hypointense signals in bone tissue (Sarto et al. 2014). The 3D Hyce sequence produced

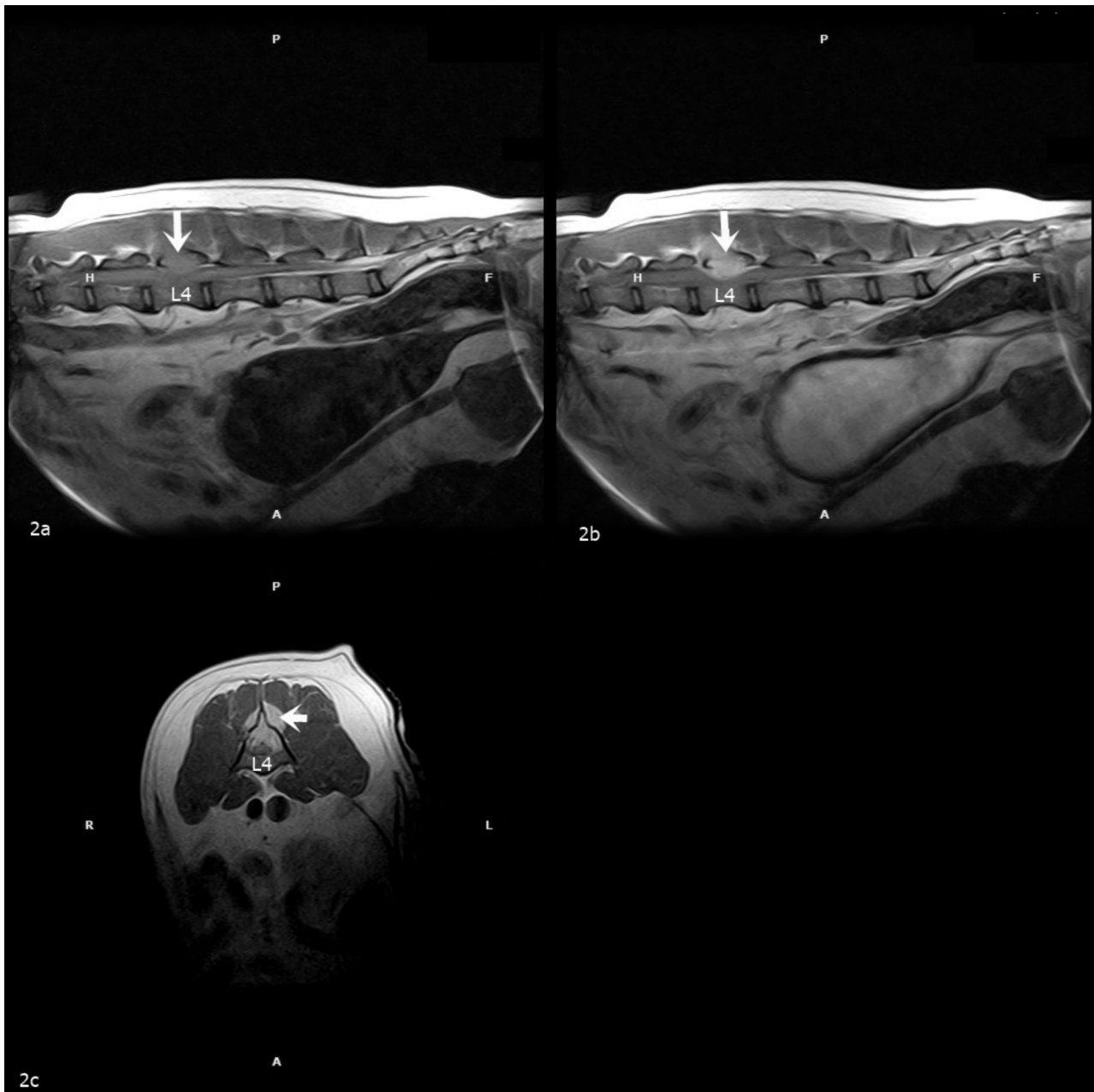


Fig. 2. a – T1-weighted Spin Echo sequence image in sagittal plane, b – postcontrast T1-weighted Spin Echo sequence image in sagittal plane, c – postcontrast T1-weighted Spin Echo sequence image in transverse plane – MRI images showing contrast enhancement on vertebral body (arrow) at the level of L4 vertebrae.

images of excellent spatial quality and the contrast between soft tissues and the hyperintense cerebrospinal fluid delivered similar effects to myelography (Sarto et al. 2014).

Intervertebral disc degeneration

Magnetic resonance imaging scans were performed on clinical patients of both chondrodystrophic and non-chondrodystrophic breeds. Chondrodys-

trophic dogs were significantly more often diagnosed with Hansen type I disc herniation where the nucleus pulposus compresses the spinal cord which is displaced due to the rupture of a degenerated fibrous ring (Hecht et al. 2009). In non-chondrodystrophic breeds, the nucleus pulposus and the degenerated fibrous ring herniate into the spinal cord (Hecht et al. 2009). In the presented group the highest incidence of intervertebral disc disease in cervical region was revealed in Dachshunds, in thoracolumbar region in Labrador Retrievers and in lumbosacral region

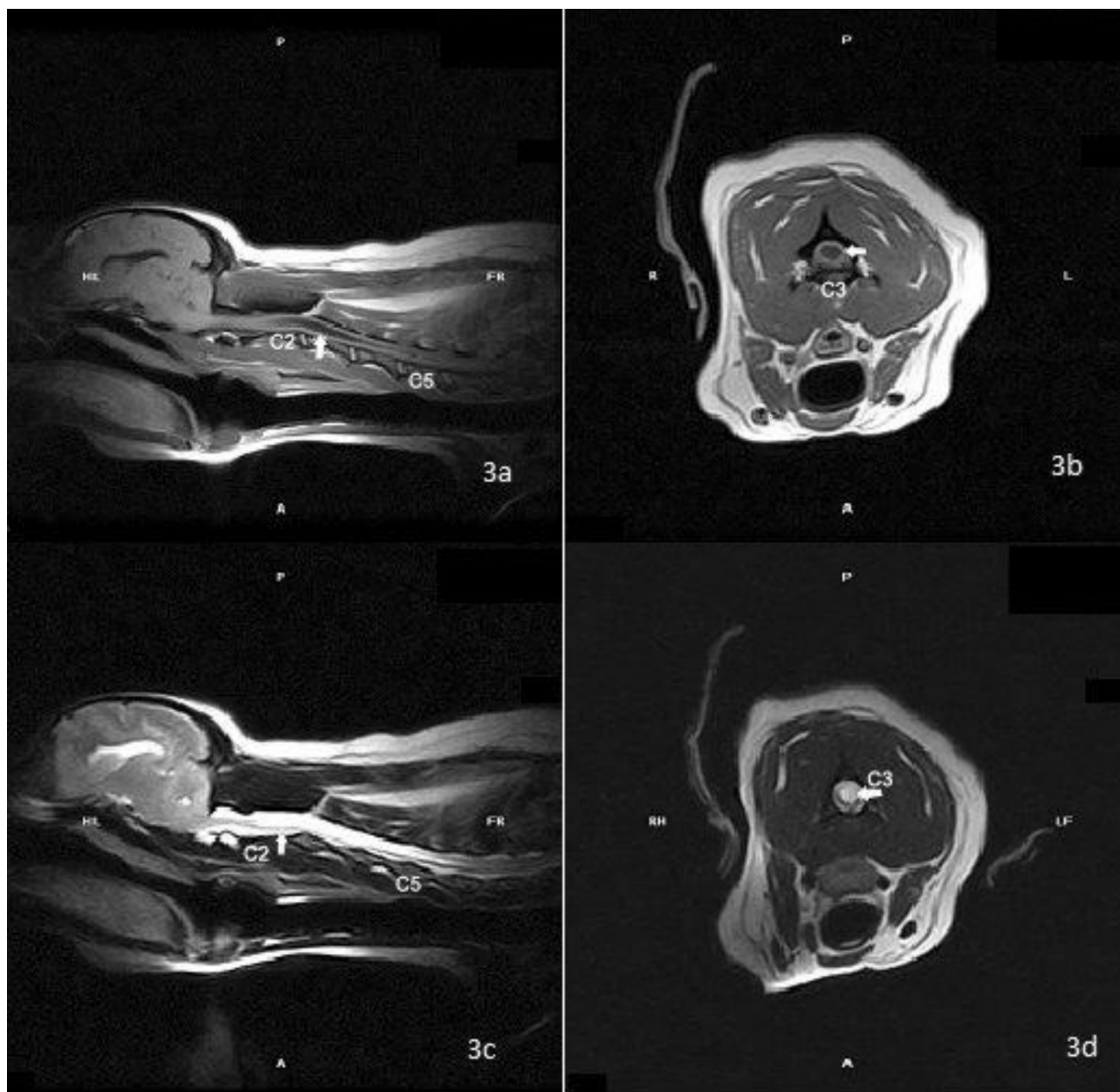


Fig. 3. a – T1-weighted Spin Echo sequence image in sagittal plane, b – T1-weighted Spin Echo image in transverse plane, c – T2-weighted Fast Spin Echo sequence image in sagittal plane, d – T2-weighted Fast Spin Echo sequence image in transverse plane – MRI images of the brain and cervical spinal cord from dog with Chiari malformation and syringomyelia (arrow).

in German Shepherds. The most of the dogs with IDD was older than six. Disc herniation in the thoracolumbar region is the most common cause of paresis in dogs (Necas 1999). In the examined group, disc herniation was also most commonly observed in the thoracolumbar region, in particular in the Th13-L1 intervertebral disc space. In a study by Penning et al. (2006), thoracic dysfunctions were most often observed in the Th13-L1 segment (34.3%), followed by the Th12-Th13 region (28.4%). Other authors reported the highest incidence of 5 displacements in the

Th12-L2 region (Knecht 1972, Gage 1975, Brown et al. 1977, Macias et al. 2002). Pathological changes in this section of the spine are accompanied by severe clinical symptoms due to the low ratio of spinal cord area to spinal cord diameter but in the Th2-Th10 region, displacement in the cranial direction is rarely noted due to the presence of intercaped ligaments which support the spinal canal (Fig. 1a,b). The applied sequences supported the evaluation of changes in the spinal cord based on its deformation, displacement or changes in signal intensity. The severity of the

observed changes was an important prognostic factor. The localization of intervertebral discs was evaluated in the sagittal plane, and disc herniation was classified as central, right-sided or left-sided in the transverse plane. Spinal disc hydration was also evaluated. Desiccation was identified based on the weaker intensity of the nucleus pulposus signal in T2-weighted sequences. A hypointense signal in the T2-weighted sequence indicates that the hydration level in the nucleus pulposus was reduced to 70%. Those changes were most visible in the sagittal plane, and they were used to compare adjacent intervertebral disc spaces.

Contrast medium uptake

Higher uptake of the contrast medium in the spinal cord is indicative of increased permeability of the blood-spinal cord barrier due to pathological processes (Dennis 2011). Tumors and inflammatory diseases can produce symptoms similar to those observed in disc extrusion (Hecht et al. 2009). After the administration of the contrast agent, the postcontrast T1-weighted sequence was used to identify and evaluate the severity of changes with increased uptake of the contrast medium (Fig 2a,b,c). Tumors were characterized by significantly higher postcontrast signal intensity than inflamed nervous tissue due to intense neovascularization typical of neoplastic growth. Those findings provided a basis for a preliminary diagnosis. In 13.4% patients, MRI scans revealed the presence of non-homogeneous hyperintense mass in the region of the vertebral body or spinous processes. Administration of the gadolinium produced moderate to strong contrast uptake of the pathological mass in all subjects.

Syringomyelia

Cavernous changes inside the spinal cord include hydromyalias communicating with cerebral ventricles, which are often dilated, and primary syringomyelias which involve widening of the spinal cord cavity. Syringomyelias include cavernous dilation of spinal cord parenchyma that does not communicate with the central canal and is not directly localized in the canal (Taga et al. 2000). In T1-weighted sequences, ventricular widening and spinal cord cavities filled with cerebrospinal fluid were characterized by low signal intensity (Fig. 3a,b), whereas high signal intensity was observed in T2-weighted sequences (Fig. 3c,d). The images acquired in the sagittal plane were used to determine the extensiveness of pathological changes

which were classified as hydromyalias or syringomyelias based on their communication with the cerebral ventricular system (Fig. 3c). The extensiveness of changes was an important prognostic factor. The syringomyelias was only observed in Cavalier King Charles Spaniels and these findings are consistent with breed predilection.

Conclusions

The proposed protocol for low-field MRI with the use of T1-SE, T2-FSE and 3D-HYCE sequences supports the acquisition of diagnostically useful images in the examination of pathological changes in the canine spine. The 3D Hyce sequence produced images of good contrast between the soft tissues and the hyperintense cerebrospinal fluid delivered similar effects to myelography. The T1-SE and T2-FSE sequences in the sagittal plane supported the evaluation of intervertebral disc location, and in transverse plane made possible to classify disc herniation as central, right-sided or left-sided. The T1-SE was used as a post-contrast sequence also. The above sequences produced images of high quality within a short scanning time and effectively revealed the presence of various abnormalities such as: disc protrusion and extrusion, disc dehydration, neoplasia and syringomyelia.

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