Intraobserver and interobserver agreement for results of low-field magnetic resonance imaging in dogs with and without clinical signs of disk-associated wobbler syndrome

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Objective—To determine interobserver and intraobserver agreement for results of low-field magnetic resonance imaging (MRI) in dogs with and without disk-associated wobbler syndrome (DAWS).

Design—Validation study.

Animals—21 dogs with and 23 dogs without clinical signs of DAWS.

Procedures—For each dog, MRI of the cervical vertebral column was performed. The MRI studies were presented in a randomized sequence to 4 board-certified radiologists blinded to clinical status. Observers assessed degree of disk degeneration, disk-associated and dorsal compression, alterations in intraspinal signal intensity (ISI), vertebral body abnormalities, and new bone formation and categorized each study as originating from a clinically affected or clinically normal dog. Interobserver agreement was calculated for 44 initial measurements for each observer. Intraobserver agreement was calculated for 11 replicate measurements for each observer.

Results—There was good interobserver agreement for ratings of disk degeneration and vertebral body abnormalities and moderate interobserver agreement for ratings of disk-associated compression, dorsal compression, alterations in ISI, new bone formation, and suspected clinical status. There was very good intraobserver agreement for ratings of disk degeneration, disk-associated compression, alterations in ISI, vertebral body abnormalities, and suspected clinical status. There was good intraobserver agreement for ratings of dorsal compression and new bone formation. Two of 21 clinically affected dogs were erroneously categorized as clinically normal, and 4 of 23 clinically normal dogs were erroneously categorized as clinically affected.

Conclusions and Clinical Relevance—Results suggested that variability exists among observers with regard to results of MRI in dogs with DAWS and that MRI could lead to false-positive and false-negative assessments. (J Am Vet Med Assoc 2011;238:74–80)

The term cervical spondylomyelopathy or wobbler syndrome refers to a collection of disorders of the caudal cervical vertebrae and intervertebral disks of large-breed dogs resulting in progressive spinal cord compression.1 A large variety of lesions with various proposed etiologies have been attributed to wobbler syndrome, and many synonyms are found in the literature.2–4 All of these clinical entities result in the same clinical signs, which can range from cervical hyperesthesia to tetraplegia. The most common clinical abnormality is a gait disturbance. Ataxia, paresis, or both affecting the pelvic limbs are usually noted, sometimes in combination with a short, stilted gait affecting the thoracic limbs.1,11 The term wobbler syndrome only refers to the characteristic wobbling seen in dogs with hind limb ataxia.1 Over the years, a few separate entities have been recognized on the basis of typical signal and pathological changes.11 The most typical

Abbreviations

DAWS Disk-associated wobbler syndrome
ISI Intraspinal signal intensity
MRI Magnetic resonance imaging
and predominant of these syndromes is DAWS. This condition is particularly seen in middle-aged to older large-breed dogs, with Doberman Pinschers being over-represented. In dogs with DAWS, caudal cervical spinal cord compression results from protrusion of 1 or more intervertebral disks, with generally mild vertebral malformations, frequently in combination with dorsal compression resulting from hypertrophy of the ligamentum flavum. Until recently, plain radiography, myelography, and computed tomography, alone or in combination, were used to confirm a diagnosis of DAWS. However, in the past decade, the use of MRI for diagnosis has increased because it is a safe, noninvasive procedure that involves no radiation, allows images to be obtained in multiple anatomic planes without the need for reconstruction, and provides superior resolution of soft tissue structures. Excellent sensitivity (ie, a low prevalence of false-negative findings) has been reported for MRI when used for the identification of neural compression associated with mechanical lesions in the vertebral canal. However, the important issue of specificity (ie, the prevalence of false-positive findings) needs clarification. Recent studies have demonstrated cervical spinal cord compression in clinically normal Doberman Pinschers and Foxhounds. This finding was more common in older dogs and most often involved the more caudally located intervertebral disk spaces. It was suggested that these subclinical compressive lesions were probably part of the common aging process of spinal degeneration. In the present study, low-field MRI studies of dogs that had both a radiologic diagnosis of DAWS and well-defined clinical signs associated with this abnormality were combined with MRI studies of age-matched clinically normal Doberman Pinschers and Foxhounds, and images were randomly interpreted by 4 independent board-certified radiologists. The purpose of the study was to evaluate inter- and intraobserver agreement for various MRI findings and quantify the frequency of false-positive and false-negative MRI assessments.

Materials and Methods

Animals—Forty-four dogs were prospectively enrolled in the study, which was conducted in accordance with the guidelines of the Animal Care Committee of the University of Ghent. Written owner consent was obtained prior to study enrollment. Dogs enrolled in the study consisted of 3 groups. The first group consisted of 21 dogs of various breeds with clinical signs and imaging findings compatible with a diagnosis of DAWS. Sixteen of these dogs were Doberman Pinschers. Other breeds included in this group were Dalmatian (n = 2), Whippet (2), and Weimeraner (1). Clinical signs ranged from cervical hyperesthesia only (n = 3) to ambulatory paraparesis and ataxia with or without cervical hyperesthesia (3), ambulatory tetraparesis and ataxia with or without cervical hyperesthesia (10), and nonambulatory tetraparesis with or without cervical hyperesthesia (5). This group consisted of 10 males and 11 females between 4.6 and 10.75 years old (mean, 7.8 years; median, 7.4 years).

The second group consisted of 12 age-matched, client-owned, clinically normal Doberman Pinschers. Dogs of this breed were selected for inclusion because of their known predisposition to DAWS. This group included 6 males and 6 females between 4.6 and 8 years old (mean, 6.3 years; median, 6 years).

The third group consisted of 11 age-matched, client-owned (n = 9) and laboratory-owned (2) clinically normal Foxhounds. Dogs of this breed were selected for inclusion because they had a body conformation and activity level comparable to that of Doberman Pinschers and were not predisposed to neurologic syndromes affecting the caudal cervical vertebral canal and spinal cord. This group included 5 males and 6 females between 4.4 and 12 years old (mean, 6.9 years; median, 6 years).

For all dogs, complete physical and neurologic examinations, a CBC, and serum biochemistry analyses were performed. All Doberman Pinschers also underwent an echocardiographic examination and standardized measurement of mucosal bleeding times. All 11 clinically normal Foxhounds and 11 of the 12 clinically normal Doberman Pinschers underwent follow-up physical and neurologic examinations between 16 and 18 months after the initial MRI examination. The goal of this second neurologic examination was to determine whether any recorded MRI abnormalities in these clinically normal dogs could be regarded as truly clinically unimportant or rather should have been regarded as indicative of an early onset of disease prior to development of clinical signs. Neurologic examinations of all dogs were performed by a single individual (SDD).

MRI protocol—A permanent 0.2-T magnet was used to perform MRI in all dogs. All MRI examinations were performed at Ghent University. Dogs were anesthetized for MRI; anesthesia was induced with propofol administered IV via a catheter placed in the cephalic vein and maintained with isoflurane in oxygen. Dogs were positioned in dorsal recumbency with the head and neck extended. The forelimbs were positioned parallel to the thorax. The cervical portion of the spine was positioned in a joint coil (circular transmit-receive coil) with an inner diameter of 19 cm. T1-weighted spin echo and T2-weighted fast spin echo studies were performed in all dogs in the sagittal, dorsal, and transverse planes. Images obtained in the transverse plane were aligned perpendicular to the cervical portion of the spinal cord. The vertebral column was imaged from the second to the seventh cervical vertebrae in the sagittal and dorsal planes and from the fourth to the seventh cervical vertebrae in the transverse plane. For all dogs, the field of view was 29 cm in the sagittal plane, 24 cm in the dorsal plane, and 20 cm in the transverse plane. Slice thickness was 4 mm for images in the sagittal and dorsal planes and 3 mm for images in the transverse plane, with no interslice gap.

Interpretation of magnetic resonance images—Copies of MRI studies for all 44 dogs, along with duplicates of 11 studies, were presented in a randomized sequence to 4 independent board-certified radiologists from 4 institutions. The randomization sequence was determined by use of a randomization software program. Eleven different studies were duplicated for each of the 4 observers, so that all 44 studies were included in the evaluation.
analysis of intraobserver agreement. The observers had no knowledge of the identity or clinical status of the dogs. The radiologists assessed and graded all studies on the basis of predefined criteria with the assistance of a standardized questionnaire. Radiologists were provided with written instructions and example figures to assist them in their assessments.

For each of the studies, observers assessed the degree of disk degeneration, disk-associated (ventral) spinal cord compression, dorsal spinal cord compression, alterations in ISL, vertebral body abnormalities, and new bone formation (spondylosis deformans). Intervertebral disk spaces C2-3 through C6-7 were evaluated on sagittal images, and intervertebral disk spaces C8-5 through C6-7 were evaluated on transverse images. Because disk degeneration is associated with decreased signal intensity on T2-weighted images,12 intervertebral disk degeneration was subjectively evaluated on the basis of signal intensity of each intervertebral disk on midsagittal T2-weighted images. A nondegenerated disk (score 0) was assumed when there was a homogenous hyperintense signal; partial disk degeneration (score 1) was assumed when there was heterogeneous loss of the hyperintense signal; complete disk degeneration (score 2) was assumed when there was a complete loss of the hyperintense signal. Disk-associated spinal cord compression was assessed on midsagittal images and, when possible, confirmed on transverse (C4 through C7) T2-weighted images. A score of 0 was assigned if there was no compression, a score of 1 was assigned if there was partial ventral subarachnoid space compression, a score of 2 was assigned if there was complete ventral subarachnoid space compression without spinal cord compression, and a score of 3 was assigned if there was spinal cord compression with deviation or distortion of the spinal cord. Dorsal spinal cord compression was evaluated on the same images and with the same scoring system as for disk-associated spinal cord compression. Alterations in ISL (present vs absent) were assessed on the basis of the relative decrease in signal on T1-weighted images and the relative decrease in signal on T1-weighted images, compared with the surrounding spinal cord parenchyma. Vertebral body abnormalities (present vs absent) were evaluated on midsagittal T1-weighted images. Vertebral body abnormalities (present vs absent) were defined as various degrees of flattening of the cranioventral border of the vertebral body. New bone formation was subjectively assessed as being present or absent.

The radiologists were also asked to indicate, for each study, whether they suspected that it represented a clinically affected dog (ie, a dog with DAWS) or a clinically normal dog. A consensus opinion was obtained when at least 3 of the 4 observers agreed that the severity of the MRI abnormalities was sufficient to cause clinical signs.

Data analysis—Inter- and intraobserver agreement in ratings of MRI findings were summarized by use of \( \kappa \) and weighted \( \kappa \) statistics.17 Weighted \( \kappa \) values were calculated for ordinal data with ≥2 possible scores (disk degeneration, disk-associated spinal cord compression, and dorsal spinal cord compression). Intraobserver agreement was calculated on the basis of results for the original 44 MRI studies examined by each observer. Intraobserver agreement was calculated on the basis of results for the 11 duplicate MRI studies examined by each observer. The strength of agreement was interpreted on the basis of the \( \kappa \) values, as suggested by Altman18 and adapted from the method of Landis and Koch.17 In brief, \( \kappa \) values of 0.81 to 1.00 were considered indicative of very good agreement, values of 0.61 to 0.80 were considered indicative of good agreement, values of 0.41 to 0.60 were considered indicative of moderate agreement, values of 0.21 to 0.40 were considered indicative of fair agreement, and values ≤0.20 were considered indicative of poor agreement. Sensitivity and specificity of MRI were calculated for all 4 observers as a group on the basis of consensus opinions and separately for each observer.

For all MRI variables, the 3 clinical groups were compared by use of the sum of the scores (with absent assigned a score of 0 and present assigned a score of 1) assigned by all 4 observers for the various intervertebral disk spaces. If a part of the image could not be interpreted, the respective intervertebral disk spaces were not included in the statistical analysis. The 3 clinical groups were first compared globally by use of the Kruskall-Wallis test; pairwise comparisons were performed with the Wilcoxon rank sum test. For the pairwise comparisons, significance was set at a value of \( P < 0.013 \) (Bonferroni correction). The effect of the MRI variables on clinical status (clinically normal vs clinically affected) was evaluated by use of logistic regression and calculation of odds ratios. We compared clinically affected dogs with all clinically normal dogs (clinically normal Doberman Pinschers and clinically normal Foxhounds) and clinically affected dogs with clinically normal Doberman Pinschers. Significance was set at a value of \( P < 0.025 \) (Bonferroni correction). If no Bonferroni correction was used, significance was set at a value of \( P < 0.05 \) (global comparisons). All statistical analyses were performed with a commercially available software program.

Results

The main artifact encountered during examination of magnetic resonance images was truncation artifact (Figure 1). None of the clinically normal dogs had signs of cervical hyperesthesia or myelopathy during the follow-up examination.

Interobserver agreement—Overall, there was good interobserver agreement for ratings of disk degeneration (\( \kappa = 0.67 \)) and vertebral body abnormalities.
Overall, there was a moderate agreement for ratings of disk degeneration (κ = 0.77) and moderate agreement for ratings of disk-associated compression (κ = 0.56), dorsal compression (κ = 0.51), alterations in ISI (κ = 0.41), and new bone formation (κ = 0.54). For ordinal findings (ie, disk degeneration, disk-associated compression, and dorsal compression), there was typically a difference of only 1 grade between observers. For 29 of the 44 dogs, all 4 observers agreed on the suspected clinical status. For 12 dogs, 3 of the observers agreed on suspected clinical status. For the remaining 3 dogs, only 2 observers agreed on suspected clinical status. There was moderate overall interobserver agreement (κ = 0.54) with regard to suspected clinical status (Table 1).

**Intraobserver agreement**—Overall, there was very good intraobserver agreement for ratings of disk degeneration (κ = 0.87), disk-associated compression (κ = 0.81), alterations in ISI (κ = 0.82), vertebral body abnormalities (κ = 0.89), and suspected clinical status (κ = 0.91). There was good intraobserver agreement for ratings of dorsal compression (κ = 0.77) and new bone formation (κ = 0.73; Table 2).

**Assessment of suspected clinical status**—When consensus opinion was compared with true clinical status, 2 of the 21 (10%) clinically affected dogs were erroneously categorized as clinically normal on the basis of MRI findings (Figure 2), and 4 of the 23 (17%) clinically normal dogs were erroneously categorized as clinically affected (2 clinically normal Doberman Pinschers and 2 clinically normal Foxhounds; Figure 3). In 3 of the 44 (6.8%) dogs, no consensus opinion was reached (1 clinically normal Doberman Pinscher and 2 clinically normal Foxhounds). In these 3 dogs, 2 observers suspected the dogs to be clinically affected, whereas the 2 other observers suspected the dogs to be clinically normal. For individual observers, sensitivity of low-field MRI for determining clinical status ranged from 0.76 to 0.90 and...
specificity ranged from 0.65 to 0.83. When consensus opinions were considered, sensitivity of low-field MRI was 0.85 and specificity was 0.71 (Table 3).

Comparison of MRI variables—For all of the MRI variables, with the exception of new bone formation, there were significant differences in scores between clinically affected dogs and dogs in each of the 2 clinically normal groups (Table 4). However, there were no significant differences for any of the variables when scores for clinically normal Foxhounds were compared with scores for clinically normal Doberman Pinschers. Examination of odds ratios indicated that the presence of an abnormality or increase in score (ie, disk degeneration, disk-associated compression, and dorsal compression) was significantly associated with an increase in the odds that a dog would be clinically affected. The odds ratios were highest for alterations in ISI and vertebral body abnormalities.

Discussion

In the present study, we determined inter- and intraobserver agreement for results of low-field MRI in dogs with and without clinical signs of DAWS and found very good intraobserver agreement for most variables but lower interobserver agreement. Further, we found that low-field MRI could lead to a substan-

Table 3—Suspected clinical status, determined on the basis of MRI findings, for 44 dogs with and without clinical signs of DAWS.

<table>
<thead>
<tr>
<th>Assessed dogs</th>
<th>Observer 1</th>
<th>Observer 2</th>
<th>Observer 3</th>
<th>Observer 4</th>
<th>Consensus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinically affected dogs</td>
<td>19</td>
<td>18</td>
<td>16</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>Rated as clinically normal</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Clinically normal DP</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Rated as clinically affected</td>
<td>9</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>10*</td>
</tr>
<tr>
<td>Rated as clinically normal</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Clinically normal FH</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Rated as clinically affected</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>9</td>
<td>9*</td>
</tr>
<tr>
<td>Rated as clinically normal</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>9</td>
<td>9*</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>0.90</td>
<td>0.96</td>
<td>0.76</td>
<td>0.88</td>
<td>0.85</td>
</tr>
<tr>
<td>Specificity</td>
<td>0.65</td>
<td>0.70</td>
<td>0.65</td>
<td>0.83</td>
<td>0.71</td>
</tr>
</tbody>
</table>

*Data are given as number of dogs.
*Consensus opinions (ie, agreement for 3 of the 4 observers) were not obtained for 1 clinically normal Doberman Pinscher and 2 clinically normal Foxhounds.

DP = Doberman Pinscher; FH = Foxhound.

Table 4—Comparison of scores for abnormalities (sum of scores for 4 independent observers) on MRI studies of 3 groups of dogs.

<table>
<thead>
<tr>
<th>Variable</th>
<th>All groups</th>
<th>Groups 1 and 2*</th>
<th>Groups 1 and 3*</th>
<th>Groups 2 and 3*</th>
<th>OR (P value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk degeneration</td>
<td>0.001</td>
<td>0.002</td>
<td>0.005</td>
<td>0.42</td>
<td>1.25 (0.002)</td>
</tr>
<tr>
<td>Disk-associated compression</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>0.003</td>
<td>0.064</td>
<td>1.20 (&lt; 0.001)</td>
</tr>
<tr>
<td>Dorsal compression</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>0.002</td>
<td>0.69</td>
<td>1.28 (0.001)</td>
</tr>
<tr>
<td>Alterations in ISI</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>0.54</td>
<td>2.88 (&lt; 0.001)</td>
</tr>
<tr>
<td>Vertebral body abnormalities</td>
<td>0.001</td>
<td>0.013</td>
<td>0.001</td>
<td>0.29</td>
<td>2.10 (0.002)</td>
</tr>
<tr>
<td>New bone formation</td>
<td>0.006</td>
<td>0.003</td>
<td>0.050</td>
<td>0.25</td>
<td>1.64 (0.010)</td>
</tr>
</tbody>
</table>

*Data represent the P values for comparisons of scores for groups.
Group 1 = Clinically affected dogs (n = 21). Group 2 = Clinically normal Doberman Pinschers (n = 12). Group 3 = Clinically normal Foxhounds (n = 11). OR = Odds ratio for clinically affected versus clinically normal dogs. For pairwise comparisons, values of P < 0.013 were considered significant (Bonferroni correction).
tial number of false-positive assessments and a lesser number of false-negative assessments of likely clinical status. Specifically, 2 of the 21 (10%) clinically affected dogs were erroneously categorized, on the basis of MRI findings, as being clinically normal, and 4 of the 23 (17%) clinically normal dogs were erroneously categorized as clinically affected. To our knowledge, no analogous studies have been done in veterinary medicine.

In the present study, we found that intraobserver agreement was very good and interobserver agreement was moderate for all MRI variables except vertebral body abnormalities and disk degeneration. Thus, although each observer was very consistent in interpreting MRI studies, some variability existed between observers despite use of standardized definitions and observer expertise. These findings were in agreement with results of comparable studies in which intraobserver agreement was generally consistently higher than interobserver agreement. Because the 4 observers in the present study were from 4 different institutions, the moderate interobserver agreement could reflect different approaches to the interpretation of MRI studies. For ordinal variables in the present study (ie, disk degeneration, disk-associated compression, and dorsal compression), when there was a disagreement in interpretation, it generally involved a slight variation in the rating of the severity of a finding, rather than a difference of opinion as to whether the finding was present. The lowest intraobserver agreement was found for the presence of new bone formation. This can be explained by the limited ability of MRI to detect signals from dense cortical bone. It is suggested that bony spurs large enough to be filled with bone marrow can be detected more easily. The lowest interobserver agreement was found for alterations in ISI. A possible reason for this could be the fact that all MRI studies were performed with a low-field MRI device (0.2 T). In human medicine, there is some controversy about the relative advantages of high- versus low-field MRI units. Several studies have demonstrated that use of high-field MRI units results in images with higher signal-to-noise ratios, higher contrast-to-noise ratios, and better subjective global quality of the images. These advantages would be of particular importance in the assessment of the smallest intramedullary lesions; such as alterations in ISI. Another disadvantage of low-field MRI is the prolonged scanning time required to complete a study. For this reason, we only obtained transverse images of the caudal cervical region (C4 through C7) and not of the entire cervical vertebral column. However, low-field MRI is associated with lower costs related to purchase and maintenance and has the advantage of allowing access to the patient during an examination.

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Further, previous studies did not demonstrate a significant difference in diagnostic accuracy between low- and high-field MRI units, and it is known that high-field MRI units are more sensitive to certain artifacts, such as motion artifacts, chemical shift artifacts, and susceptibility artifacts. Another factor possibly contributing to the low interobserver agreement for alterations in ISI in the present study could have been the truncation artifacts in some of the MRI studies that were included (Figure 1). Most commonly, truncation artifact appears as a dark or bright line located centrally along the length of the spinal cord. This artifact can be mistaken for several pathological conditions, including dilation of the central canal or a syrinx. It occurs adjacent to areas of abrupt changes in signal intensity, such as between the spinal cord and CSF. Truncation artifacts can be eliminated by use of at least 192 phase-encoding steps, decreasing the field of view, or switching the phase and frequency encoding directions.

Because previous work has revealed a high incidence of MRI abnormalities of the cervical vertebral column in clinically normal dogs, it was not surprising that 4 of the 23 (17%) clinically normal dogs in the present study were erroneously classified on the basis of MRI findings as clinically affected. This resulted in an overall specificity of 0.71 and suggested that caution should be taken with attributing clinical signs to structural abnormalities seen on magnetic resonance images. This is especially important in large-breed dogs because several of these breeds are prone to the development of degenerative neurologic syndromes affecting the caudal cervical region. More surprising was the fact that, depending on the observer, up to 3 of the 21 clinically affected dogs were erroneously categorized as clinically normal. This resulted in an overall sensitivity of 0.85, which was lower than we had expected. These findings suggest that abnormalities seen on MRI do not always correlate with clinical signs and that minimal degenerative changes can be sufficient to cause clinical signs in dogs predisposed to DAWS, whereas other dogs apparently can tolerate more pronounced degenerative changes without the development of clinical signs. This is in agreement with findings of a recent study evaluating the morphological and morphometric MRI features of Doberman Pinschers with and without clinical signs of cervical spondylomyelopathy in which more pronounced MRI abnormalities were identified in some clinically normal Doberman Pinschers, compared with some affected dogs. In humans, relative vertebral canal stenosis is the single most important static factor that predisposes people to the development of clinically relevant cervical spondylomyelopathy. With absolute stenosis, the vertebral canal diameter is sufficiently narrow to cause direct neural compression. Relative stenosis implies a diameter that is less than what is regarded as within reference limits but that does not cause neural compression. Relative stenosis may become clinically important with the development of space-occupying conditions of the vertebral canal, such as age-related intervertebral disk degeneration and protrusion. A similar relationship has been suggested to occur in dogs.

In the present study, there was a significant difference for all assessed MRI variables when scores for clinically affected dogs were compared with scores for both groups of clinically normal dogs. The most notable difference, together with the highest odds ratio, was the presence of alterations in ISI. This was in agreement with a previous report and suggested that the presence of alterations in ISI can be considered a reliable indicator of clinically relevant spinal cord compression. A limitation of the present study was the fact that MRI was the only diagnostic modality used to com-
pare clinically affected and normal dogs. It is known that radiographic abnormalities in clinically normal dogs can also be seen with myelography, computed tomography, and computed tomography-myelography.\(^{15}\) Because most current methods of evaluating the cervical vertebral column (ie, myelography and computed tomography-myelography) are invasive,\(^{10,16}\) a comparative study involving clinically normal animals is more difficult. It should also be emphasized that MRI accurately images the anatomy of the cervical spinal cord and that abnormal findings in clinically normal animals probably represent what are generally regarded as clinically false results and not anatomically false results. The results of ongoing studies will help to differentiate between clinically relevant and irrelevant spinal cord abnormalities on magnetic resonance images and provide further information on the existence and recognition of potential anatomic risk factors, such as relative canal stenosis.

**References**