Association of preoperative magnetic resonance imaging findings with surgical features in Dachshunds with thoracolumbar intervertebral disk extrusion

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Objective—To evaluate the accuracy of specific magnetic resonance imaging (MRI) sequences in determining the site, lateralization, and extent of extruded intervertebral disk material (EIDM), compared with surgical findings, in Dachshunds with thoracolumbar intervertebral disk extrusion (TLIDE).

Design—Prospective clinical study.

Sample Population—16 Dachshunds with clinical signs of intervertebral disk disease.

Procedures—Preoperative T1-weighted, T2-weighted, and short tau inversion recovery (STIR) MRI measurements and description of the location of EIDM were compared with intraoperative measurements and determination of the EIDM position.

Results—The T12-13 intervertebral disk space was the most frequent site of EIDM (6/16 dogs). The EIDM lateralized with equal frequency to the left and right sides; no central extrusions were seen. There was moderate to substantial agreement (kappa, 0.59) between MRI and surgical findings for evaluation of the cranio-caudal distribution of the EIDM. For measurement of the length of EIDM, the T1-weighted, T2-weighted, and STIR sequences had a mean error of −1.15, −0.38, and −1.93 mm, respectively; concordance correlation coefficients were 0.666, 0.904, and 0.458, respectively. Mean absolute errors were 2.54, 1.35, and 2.90 mm, respectively; these values did not differ significantly.

Conclusions and Clinical Relevance—In the thoracolumbar vertebral column of Dachshunds with clinical signs of intervertebral disk disease, MRI is a valuable technique for determining location and cranio-caudal length of EIDM. Compared with T1-weighted and STIR images, T2-weighted images appeared to be more accurate and precise and are potentially more reliable for determination of the length of EIDM in those dogs. (J Am Vet Med Assoc 2008;232:702–708)

Intervertebral disk disease is a common neurologic condition in dogs. It is the process of IVD degeneration followed by protrusion or extrusion of disk material into the vertebral canal with focal compression of the spinal cord or adjacent nerve roots and attendant vascular structures. The clinical signs associated with IVDD range from spinal hyperesthesia to hind limb ataxia, nonambulatory hind limb paraparesis, and complete hind limb paralysis with or without loss of deep pain perception, together with various degrees of loss of sensory and motor function. Dachshunds are 12.6 times as likely to develop IVDD as any other breed of dog. Priester reported that 49% (3,898/8,117) of dogs with IVDD were Dachshunds; in another report, Dachshunds comprised 24.5% of the breeds affected by IVDD. The incidence of IVDD among high-risk dog breeds peaks between 4 and 6 years of age. The thoracolumbar junction (vertebral bodies T11 through L2) is the area most commonly affected by disk extrusion or protrusion; in dogs evaluated at Auburn University between 1952 and 1975, 1,718 of 2,620 of all disk protrusions and extrusions occurred in this anatomic region.

Surgery is recommended in most IVDD-affected dogs that have marked and deteriorating neurologic signs. For surgical candidates, specialized diagnostic imaging procedures are undertaken to confirm focal extradural cord compression and to anatomically localize and characterize the extent of the lesion. The imag-
ing findings enable the surgeon to limit access to the appropriate portion of the cord and to approach the lesion in the least invasive manner.9-11 Myelography and computed tomography have been used for spinal cord assessment but with specific limitations. Myelography provides an outline of the spinal cord but does not definitively reveal the nature of the pathologic change and can be unreliable in the presence of severe spinal cord swelling or epidural hemorrhage.12 Compared with MR imaging, computed tomography is claimed to be more versatile but provides relatively limited soft tissue definition. It has been recommended that computed tomography or MR imaging is used instead of myelography for assessment of the vertebral column in dogs.13

Magnetic resonance imaging is frequently used in the veterinary field for assessment of suspected neurologic conditions. The principal advantage is enhanced soft tissue imaging with 3-dimensional delineation of lesions. This imaging technique is noninvasive and safe for the patient. In humans, it has been proven to be the method of choice for imaging the nervous system.14-16 There are a number of reports12,17-24 describing the clinical application of MR imaging in dogs. Of these studies, some have assessed clinically normal vertebral columns,21,23-29 whereas others have assessed degenerative changes in IVDs.23,29 Magnetic resonance imaging has been reported17-19,21,23,24,28 to be a reliable diagnostic tool for IVDD in dogs and cats.

In a retrospective study28 of 40 dogs of different breeds that had IVDD and for which MR imaging and subsequent decompressive surgery had been performed, the MR imaging findings correlated with surgical observations with regard to localization and degree of disk material dispersion. Dispersed disk material was described as material that had lost contact with the originating IVD space, whereas nondispersed material retained contact with the disk space. In that study,28 there was complete agreement between the MR imaging and surgical findings with regard to left, right, or central positioning of the EIDM.

To our knowledge, there are no published prospective studies of dogs with TLIDE that have determined the accuracy of MR imaging findings; no comparison between the size and localization of the extruded material as determined via MR imaging and findings at the time of surgery has been reported. Seemingly, no study has compared different MR imaging sequences to determine which, if any, is the most accurate for assessment of the size of the extruded material. Similarly, we are not aware of any published case series to describe the MR image appearance of TLIDE in dogs and standardize findings with respect to breed, duration of clinical signs, first-time event, and anatomic location of disk extrusion. The purpose of the study reported here was to evaluate the accuracy of specific MR imaging sequences in determining the site, laterализation, and extent of EIDM, compared with surgical findings, in Dachshunds with TLIDE. Our hypotheses were that estimates of extent and location of extruded IVD material obtained via MR imaging do not differ from measurements obtained during surgery and that no differences exist among T1-weighted, T2-weighted, and STIR sequences with regard to determination of the length of EIDM.

Materials and Methods

Dogs—Sixteen Dachshunds that were admitted to Ridgemark Veterinary Hospital, Johannesburg, for treatment of suspected TLIDE. Dachshunds of any age, weight, or sex were accepted into the study. The project was approved by the Animal Use and Care Committee of the Faculty of Veterinary Science, University of Pretoria. Informed consent was obtained from all owners before inclusion of their dog in the study.

Inclusion and exclusion criteria—For any dog, a history of a suspected spinal condition of no longer than 6 weeks duration was required. Dogs with a history of severe spinal cord swelling or epidural hemorrhage that can cause susceptibility artifacts during the MR imaging procedure. Only dogs in which the preoperative MR images indicated a single TLIDE were included.

Examinations and procedures—An initial full physical and neurologic examination was performed on each dog. An MR imaging examination was performed by use of a 1.5-T MR imaging unit. The dog was premedicated with medetomidine6 (10 µg/kg [4.5 µg/lb], IV) and anesthetized on arrival at the MR imaging unit via IV injection of a 2.5% solution of thiopentone sodium5 (0.1 to 0.5 mL/kg [0.045 to 0.227 mL/lb]). After premedication, each dog received lactated Ringer’s solution5 IV (5 to 10 mL/kg/h [2.27 to 4.5 mL/lb/h]) via a cephalic vein catheter, which was maintained for 48 hours. The dog was positioned in dorsal recumbency with the hind limbs in a flexed position. All attempts were made to position each dog with its vertebral column in as straight alignment as possible. The thoracolumbar portion of the vertebral column (from vertebral bodies T10 through L7) was investigated. For each dog, T1-weighted, T2-weighted, and STIR sequences were obtained in the sagittal plane. A B-TFE sequence in the transverse plane, at the level of the extruded IVD material, was performed after the sagittal imaging. The B-TFE sequence provides good imaging detail with similar appearance to that of a T1-weighted sequence. The MR image settings used for T1-weighted images included the following: field of view, 275 mm2; matrix, 304 × 512; TE, 10 milliseconds; flip angle, 90°; TR, 400 milliseconds; and 2-mm slices with 2-mm slice gaps. The MR image settings used for T2-weighted images included the following: TE, 120 milliseconds; TR, 3,500 milliseconds; and the remainder of settings as for the T1-weighted images. The MR image settings used for STIR images included the following: inversion recovery
Before surgery, each dog was administered amoxicillin-clavulanic acid (20 mg/kg [9.1 mg/lb]) IV. A pediclectomy was performed at the location determined from the MR images. A bone window was created marginally longer than the outline of the EIDM on the sagittal MR images. The extruded material was carefully removed once the various measurements had been made. The herniating IVD was fenestrated by use of a No. 11 scalpel blade and a blunt curette. Postoperative pain control consisted of SC administration of morphine sulphate (0.3 to 0.5 mg/kg [0.14 to 0.23 mg/lb]) every 4 hours during the first 24 to 48 hours; carprofen was administered orally (4 mg/kg [1.8 mg/lb]) once daily for the first 7 days after surgery. Each dog was caged in a heated ward until fully recovered from anesthesia. Intravenous fluid therapy was continued until the dog was able to eat food. Administration of amoxicillin-clavulanic acid was repeated at 4 and 12 hours after surgery. The dog was discharged from the hospital once it could walk unassisted and void urine and feces unaided. All dogs were hospitalized for at least 72 hours.

**MR imaging findings and measurements**—Measurements were performed independently on the computerized MR images by a board-certified radiologist (WMW), who had no knowledge of the intraoperative findings. The assessor of the MR images was unaware of the specific MR sequence used, and the sequences were evaluated in random order. The herniating IVD space was identified. The maximum length of the EIDM (as seen on sagittal T1-weighted, T2-weighted, and STIR sequences) in a cranio-caudal direction was measured by use of the digital caliper of the MR imaging computer. For each sequence, 2 measurements were recorded and the mean value was used for the statistical analysis. The distribution of the EIDM (as seen on the sagittal sequences) was recorded as cranial, caudal, or equally cranial and caudal relative to the identified disk space. Transverse B-TFE sequences were used to evaluate the circumferential distribution of the EIDM; findings were recorded as dorsal, lateral, ventral, dorso-lateral, ventrolateral, or combinations thereof. The transverse images were also used to categorize the material as situated left or right of the spinal cord or exactly central in the vertebral canal. Transverse images were not used to determine the cranio-caudal length of the EIDM.

**Intraoperative findings and measurements**—During the pediclectomy, the surgeon (SHN) recorded selected measurements; after removing the pedicles of the vertebrae, a small probe was inserted to palpate the cranial and caudal extremities of the EIDM (where the disk material abutted epidural fat). A sterile manual caliper was then used to measure (to the nearest millimeter) the length of the EIDM in a cranio-caudal direction, as viewed from the lateral aspect. The position of the EIDM in relation to the affected IVD space was recorded as distributed more cranially, more caudally, or equidistant from the disk space. The position of the EIDM in relation to the spinal cord was recorded as dorsal, lateral, ventral, dorso-lateral, ventrolateral, or a combination thereof. The lateralization of the EIDM was also recorded as left or right of the spinal cord or exactly central in the vertebral canal.

**Statistical analysis**—Kappa statistics were calculated to assess agreement between each MR imaging sequence and intraoperative findings with respect to location of the herniated disk, lateralization of the EIDM, and cranio-caudal distribution of the EIDM. For the latter, a weighted kappa statistic was used; if the MR imaging sequence and intraoperative findings differed, agreement between the measurements was considered to be 50% (ie, cranial location vs location equidistant from the disk space or caudal location vs location equidistant from the disk space) or 0% (ie, cranial location vs caudal location). The intraoperative EIDM length measurement was used as a standard against which each MR imaging sequence was compared. Agreement between cranio-caudal length measurement of the compressive mass obtained from each MR imaging sequence and that obtained intraoperatively was assessed by use of a concordance correlation coefficient, which combines measures of precision and accuracy to determine deviation of observed data from the line of perfect concordance. The 99% limits of agreement were then calculated for each MR sequence measurement versus each intraoperative measurement. The mean bias, with 99% confidence intervals, was calculated for each sequence, and paired t tests were used to compare lengths measured from each MR imaging sequence with length measured during surgery. The null hypothesis tested was that there was no difference between MR imaging and surgical estimates of EIDM length. Absolute errors were also compared among MR imaging sequences by use of a repeated-measures ANOVA. Statistical analyses were done by use of statistical software. A value of P < 0.05 was considered significant.

**Results**

The mean age of the study population was 5.9 years (range, 3 to 10 years). Mean weight of the dogs was 7.56 kg (16.63 lb; range, 4 to 11 kg [8.8 to 24.2 lb]). The group consisted of 5 spayed females, 4 sexually intact males, and 7 neutered male dogs. Mean duration of clinical signs was 8.8 days (range, 1 to 42 days).

As confirmed during surgery, the specific IVD space from which the extrusion originated was T11-12 in 3 dogs, T12-13 in 6 dogs, T13-L1 in 2 dogs, L1-2 in 3 dogs, and L3-4 in 2 dogs. There was complete agreement (kappa, 1.0) regarding identification of the affected IVD space between the determination made from MR images and the determination made during surgery. There was also complete agreement (kappa, 1.0) regarding lateralization of the EIDM between the determination made from MR images and the determination made during surgery. There was no difference in the number of correct assessments among the 3 MR imaging techniques.

On the basis of the MR images, the cranio-caudal distribution of the EIDM was considered cranial in 8 dogs, caudal in 3 dogs, and equidistant from the IVD space in 5 dogs. On the basis of the intraoperative findings, the actual location of the EIDM was cranial in 8 dogs, caudal in 2 dogs, and equidistant from the IVD space in 6 dogs. Among the 16 dogs, the distribution
determined from the MR images agreed with the intraoperative finding for 11 dogs and did not agree with the intraoperative finding for 5 dogs. Overall, the weighted kappa statistic for the agreement regarding craniocaudal distribution of EIDM between the determination made from MR images and the determination made during surgery was 0.59, indicating moderate to substantial agreement. In 2 dogs for which MR images indicated equidistant distribution of EIDM from the IVD space, disk material was actually located predominantly cranial to the disk space. In 2 dogs for which MR images indicated cranial distribution of EIDM from the IVD space, disk material was actually located equidistant to the disk space. In 1 other dog, the distribution of EIDM was actually equidistant to the IVD space but the MR imaging revealed a predominantly caudal distribution. These discrepancies could be attributed to interobserver variation or could be attributable to the fact that the location was recorded before removal of any EIDM and that some material was not located accurately. The measured EIDM length determined from each MR imaging sequence versus the intraoperative measurement of the EIDM was plotted (Figures 1–3). The radiologist could not accurately obtain measurements from T1-weighted

For some dogs, the error could be attributable to the fact that the location was recorded before removal of any EIDM and that some material was not located accurately. The measured EIDM length determined from each MR imaging sequence versus the intraoperative measurement of the EIDM was plotted (Figures 1–3). The radiologist could not accurately obtain measurements from T1-weighted

![Figure 1](image1.png) Scatter plot of maximum length of EIDM determined from T1-weighted MR images of 12 Dachshunds* with TLIDE versus lengths measured during surgical treatment of those dogs. The diagonal is the line of perfect agreement; the vertical distance between each datum point and the diagonal line is the T1-weighted imaging measurement error. For these data, $r^2 = 0.478$. *Accurate measurements could not be made from T1-weighted sequences for 4 of the 16 study dogs; measurements were not recorded if no accurate reading could be obtained by use of the digital tracker on the MR imaging unit.

![Figure 2](image2.png) Scatter plot of maximum length of EIDM determined from T2-weighted MR images of 16 Dachshunds with TLIDE versus lengths measured during surgical treatment of those dogs. The diagonal is the line of perfect agreement; the vertical distance between each datum point and the diagonal line is the T2-weighted imaging measurement error. For these data, $r^2 = 0.533$.

![Figure 3](image3.png) Scatter plot of maximum length of EIDM determined from STIR MR images of 12 Dachshunds* with TLIDE versus lengths measured during surgical treatment of those dogs. The diagonal is the line of perfect agreement; the vertical distance between each datum point and the diagonal line is the STIR measurement error. For these data, $r^2 = 0.259$. *Accurate measurements could not be made from STIR sequences for 4 of the 16 study dogs; measurements were not recorded if no accurate reading could be obtained by use of the digital tracker on the MR imaging unit.

<table>
<thead>
<tr>
<th>Variable</th>
<th>T1-weighted</th>
<th>T2-weighted</th>
<th>STIR</th>
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<tr>
<td>Mean error (mm)</td>
<td>-1.2</td>
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<td>Range of errors (mm)</td>
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<td>Mean absolute error</td>
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<td>Concordance correlation</td>
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<td>0.904</td>
<td>0.458</td>
</tr>
<tr>
<td>95% limits of agreement</td>
<td>-8 to 5.8</td>
<td>-3.7 to 3</td>
<td>-10.3 to 6.4</td>
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</tbody>
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*Accurate measurements could not be made from T1-weighted sequences for 4 dogs and from STIR sequences for 4 dogs; measurements were not recorded if no accurate reading could be obtained by use of the digital tracker on the MR imaging unit. Concordance correlation coefficient of 0.95 limits of agreement for the mean error.
sequences for 4 of the dogs and from STIR sequences for 4 of the dogs in those images. Measurements were not recorded if no accurate reading could be obtained by use of the digital tracker on the MR imaging unit.

The circumferential distribution was not evaluated statistically because of the large number of categories and the relatively small sample size. Complete agreement between MR imaging findings and intraoperative observations was achieved for only 1 dog. For most dogs, there was some overlap between the MR imaging findings and intraoperative observations with regard to the circumferential distribution of the EIDM.

For the length of the EIDM, the mean error, range of errors, 95% confidence limits for the mean error, and mean absolute error for measurements from each MR imaging sequence were calculated (Table 1). The concordance correlation coefficient and 95% limits of agreement for the measurement from each MR imaging sequence with the measurement obtained during surgery were also calculated. By use of paired t tests, there were no significant differences in the mean length of the EIDM material as determined from any of the MR imaging sequences and that determined during surgery. Thus, the null hypothesis that MR image estimates of length of the EIDM were similar to the measurements obtained during surgery was not rejected.

Measurements of EIDM length performed on the T2-weighted images were the least biased, had the narrowest range of errors, and had the best overall concordance with the intraoperative measurements, compared with measurements obtained from the T1-weighted and STIR sequences. However, repeated-measures ANOVA revealed no significant (P = 0.420) differences among the absolute errors obtained by use of the 3 MR imaging sequences.

Discussion

The main objective of the present study was to evaluate the accuracy and precision of MR imaging in localizing EIDM in Dachshunds that had TLID. Another objective was to determine whether any 1 of the 3 MR imaging sequences (T1-weighted, T2-weighted, and STIR) investigated was superior in predicting the actual length of the EIDM. Our study was designed to minimize the number of potentially confounding variables and maximize the ability to detect real effects, thereby compensating for a small sample size. This was a preliminary observational study; studies involving larger case numbers will be required to critically test our findings.

In the 16 Dachshunds included in the present study, disk extrusions were equally distributed between the left and right sides. No centrally located disk extrusions were detected. This finding differs from that of a previous study in which 15% of the disk extrusions were central.

With regard to the specific IVD that extruded into the vertebral canal, there was complete agreement (kappa, 1.0) between the MR imaging and surgical findings. There was also complete agreement between the findings with regard to lateralization of the EIDM. These results support the conclusions of previous studies.

that information gained via MR imaging is highly reliable in directing a surgeon to the correct location of the pathologic change.

The craniocaudal distribution of the EIDM was categorized as being situated either predominantly cranial to the specific IVD space, predominantly caudal to the IVD space, or equally distributed cranially and caudally to the affected IVD space. With regard to this craniocaudal distribution, there was 100% agreement between MR imaging and surgical findings in 11 of the 16 dogs and only 50% agreement among the remaining 5 dogs. It is possible that the demarcations among the 3 distribution categories were not defined well enough, resulting in an overlap of descriptions, because we only attempted to record the region where most of the EIDM was situated and not the entire mass. In addition, the MR image used for the recording of the craniocaudal distribution may not have included some part of the extruded material because of the MR image slice thickness and the gap between consecutive slices. This could potentially lead to either an under- or an overestimation of the extent of the EIDM. However, this did not impede the surgeon’s ability to access and remove the extruded material because a marginally larger bone window than that indicated from the imaged boundaries was created, thereby avoiding disturbance of the EIDM for this study. For this reason, the authors recommend that to reach all extruded material, the size of the bony window created during surgery should be slightly larger than the margins of the EIDM defined on the MR images. Thinner MR imaging slices could be more accurate in delineating the EIDM, but use of such slices would result in decreased signal-to-noise ratio and less well-defined images. It is of clinical importance to determine the distribution of the extradural compression in dogs with TLIDe as accurately as possible. As a result, duration of anesthesia and surgery would be shorter, thereby decreasing the period of hypotension; achieving the latter may then have a sparing effect on an already compromised spinal cord.

In the dogs of the present study, the circumferential distribution of the EIDM was recorded intraoperatively and from measurements of MR images. The findings appeared to have good overlap but were not evaluated statistically. The discrepancies that we found were attributable to a limited view of the lateral aspect of the spinal cord and to subjective assessment of the position of the material.

In the study of this report, measurements for each of the 3 MR imaging sequences typically underestimated the size of the EIDM that was identified during surgery; T2-weighted image measurements were the most accurate (mean error closest to zero). Measurements derived from the T2-weighted images also had the narrowest range of errors, compared with measurements made from the other sequences. This indicated that a T2-weighted image measurement was the most precise measure. Overall, it is clinically more relevant to have measurements that are reliably close to the true value (a combination of accuracy and precision), rather than merely rely on whether those measurements are typically greater or smaller than the true value. The con-
cordance correlation coefficient provided a summary measure of accuracy and precision and indicated that measurements from the T2-weighted sequence agreed more closely with the measurement determined during surgery than did the measurements from the other 2 sequences. This agreement was also reflected in the fact that the measurements from the T2-weighted sequence had the lowest mean absolute error. However, there was no significant difference among the mean absolute errors for measurements obtained from the various sequences. This may have been a consequence of the small sample size in our study. Differences in measurements among the 3 specific MR imaging sequences were probably caused by the variation in image quality and the ease with which borders of lesions could be identified. We suspect that the contrasting appearance of differing types of tissues in T2-weighted images improved our ability to accurately measure the length of the EIDM.

In the present study, the intraoperative findings used for comparison with MR imaging findings did not represent a true gold standard because the vertebral canal was only viewed through a limited bone window. However, application of any other standard would not have been practical. The only absolute gold standard would have been postmortem evaluation and measurement, which is obviously not ethical or possible for an investigation of this type.

The measurement of the length of the EIDM during surgery could have been a problem in our study because the sterile caliper had to be placed within the surgical wound and possibly interfered with the task of recording an accurate measurement. This did not seem to affect our ability to perform measurements because they correlated closely to the MR image findings. Also, whether the EIDM was calcified was not recorded; calcification could have decreased the accuracy of some measurements obtained from MR images because the decreased hydrogen content could have affected the imaging characteristics of the EIDM.

Another concern in the present study was that the EIDM could be disturbed or displaced during surgical entry into the vertebral canal. The possibility also existed that we measured the most lateral aspect of the EIDM and not necessarily the maximum distribution in a cranio-caudal direction. The disadvantage of the intraoperative examination was that visibility was reduced as a result of concurrent hemorrhage and limited access to the vertebral canal (because of the size of the bone window); it was also possible that the disturbance of the extruded material occurred on entering the vertebral canal. Nevertheless, it was still easier than expected to perform the intraoperative measurements.

Undoubtedly, the surgeon involved in the present study knew the predicted herniated IVD space and the predicted lateralization of the EIDM; this person also had an indication of the length of the EIDM but no actual measurement. This lack of blinding introduced a potential bias in our study. Future investigations should be conducted by persons who are completely unaware of the location of the EIDM; nevertheless, the surgeon would still need to know the level of extrusion and the lateralization. A second observer could be used to record the findings after surgical exposure. The caliper used had slightly broad pincers, and this method could be improved by use of a specially designed device with thin and elongated pincers, which could be positioned with the measuring section away from the surgical wound and only the pincers positioned within the vertebral canal.

Performing measurements on the MR imaging unit computer by use of the digital tracker proved difficult to execute because the tracker was superimposed over parts of the pathologic change and made it difficult to obtain an exact measurement. The MR images were measured twice to obtain a mean reading, and the measurements were not performed concurrently. The readings for each dog rarely differed by more than 1 to 2 mm, and a third set of measurements was not deemed necessary. The radiologist could not accurately obtain measurements from T1-weighted sequences for 4 of the dogs and from STIR sequences for 4 of the dogs; in those images, it was highly difficult to define the cranial and caudal borders of the EIDM and determine the exact position of the mass. On the T2-weighted images, the distinction between the EIDM and the surrounding tissues was more clearly delineated. Measurements were not recorded if no accurate reading could be obtained by use of the digital tracker on the MR imaging unit.

Comparison of the length of the EIDM as determined intraoperatively with measurements obtained from the MR images revealed information not previously reported, namely the close agreement between these length measurements. To the authors’ knowledge, this is the first study in which these types of measurements were compared; in our opinion, the measurements made by use of these methods were repeatable and could be used in future studies.

It is also our opinion that MR imaging improved the quality of the surgery (compared with procedures that rely on myelographic elucidation of EIDM) in the dogs of this report because the extent of the extruded mass as observed on the images corresponded closely to that seen during the surgical procedure. Determination of the location and extent of IVD extrusions prior to surgical intervention is a critical factor for a successful outcome. Magnetic resonance imaging information, such as that determined in dogs with TLIDE in our study, can help surgeons to remove the maximum amount of EIDM with the minimum amount of nerve tissue manipulation and surgical time.

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