Recurrence of disk herniation following percutaneous laser disk ablation in dogs with a history of thoracolumbar intervertebral disk herniation: 303 cases (1994–2011)

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OBJECTIVE
To determine rate of recurrence of disk herniation in dogs that underwent percutaneous laser disk ablation (PLDA) because of a previous episode of suspected or confirmed thoracolumbar intervertebral disk herniation (IVDH).

DESIGN
Retrospective case series.

ANIMALS
303 dogs that underwent PLDA and for which a minimum of 3 years of follow-up information was available (n = 294) or for which recurrence was documented within 3 years after the procedure (9).

PROCEDURES
Information on signalment, previous episodes of IVDH, specifics of the PLDA procedure, and recurrence was obtained from the medical records. Owners were contacted to complete a questionnaire regarding outcome and recurrence.

RESULTS
60 of the 303 (19.8%) dogs had an episode of suspected or confirmed IVDH after undergoing PLDA, but only 11 of the 303 (3.6%) dogs had a recurrence of IVDH confirmed by means of CT or MRI and hemilaminectomy. Recurrence rate following PLDA was not significantly different between dogs that had been treated medically for previous episodes of IVDH and dogs that had been treated surgically. Overall, 270 of 286 (94.4%) owners reported that their dog was the same (109 [38.1%]) or improved (161 [56.3%]) immediately after PLDA, and 265 (92.7%) owners rated their satisfaction with the procedure as ≥ 9 on a scale from 1 (completely dissatisfied) to 10 (completely satisfied).

CONCLUSIONS AND CLINICAL RELEVANCE
Results suggested that PLDA was a relatively safe, minimally invasive procedure associated with a low rate of recurrence of disk herniation when performed in dogs with a history of previous episodes of suspected or confirmed IVDH. (*J Am Vet Med Assoc* 2016;249:1393–1400)

Use of a laser for percutaneous photothermal ablation of the nucleus pulposus of the lumbar disks has been reported as a treatment for IVDH in human patients.[1-7] Reported advantages include decreased invasiveness, reduced morbidity rates, shorter intervention times, and lower rates of recurrence of IVDH. The Ho:YAG laser has been shown to provide optimum laser ablation of the nucleus pulposus in humans.[1] A particular advantage of the Ho:YAG laser is that it emits a wavelength that is strongly absorbed by water, allowing depth of penetration to be limited and zones of necrosis and collateral thermal effects to be minimized.[8]

ABBREVIATIONS

Ho:YAG	Holmium:yttrium-aluminum-garnet
IQR	Interquartile range (ie, 75th minus 25th percentile)
IVDH	Intervertebral disk herniation
PLDA	Percutaneous laser disk ablation

There has been some controversy regarding the efficacy of laser diskectomy in human medicine because disk morphology does not appear to be altered on MRI images[4] and surgical outcomes may reflect a natural progression of healing.[5] On the other hand, various studies[6,9-11] have shown the procedure to be safe and effective, with reported success rates ranging from 76% to 94.5%. Proponents of the procedure in human medicine suggest that the positive effects of laser ablation may be a result of decreased intradiskal pressure caused by a reduction in the volume of the nucleus pulposus subsequent to ablation.[7,8]

Recurrence rates following treatment of dogs with IVDH have been reported to range from 2.6% to 41.7%.[12-15] Surgical fenestration has been recommended as a prophylactic procedure to prevent further herniation of the nucleus pulposus, and recurrence rates following fenestration have been reported to range from 0% to 24.4%.[13-16] However, 2 recent studies re-

ported confirmed first-time recurrence rates of 2.3% to 12.7% after fenestration,[13,17] and Brisson et al[13] in a prospective, randomized study found first-time recurrence rates of 17.9% following single-site disk fenestration and 7.5% following multiple-site disk fenestration.

Percutaneous laser disk ablation was developed as an alternative, minimally invasive method for decreasing the risk of recurrence in dogs that have had an episode of IVDH.[18] A retrospective study[19] of 277 dogs that underwent PLDA between 1992 and 2001 found that 3.4% of the dogs subsequently developed paresis or paralysis, with follow-up times ranging from 1 to 85 months. Since that study, Mayhew et al[12] published a retrospective study showing that 96% of recurrences in their patient population occurred within 3 years after the initial decompressive surgery for an episode of disk herniation. Therefore, the purpose of the study reported here was to determine recurrence rate and factors associated with recurrence in dogs that underwent PLDA because of a previous episode of suspected or confirmed thoracolumbar IVDH and were followed up for a minimum of 3 years. Our hypothesis was that the overall recurrence rate would be similar to the 3.4% rate reported by Bartels et al.[19] Cases included in the study by Bartels et al[19] for which long-term (ie, ≥ 3 years) follow-up information was not available were also included in the present study.

Materials and Methods

Case selection criteria

Medical records of the Oklahoma State University Center for Veterinary Health Sciences, Boren Veterinary Medical Hospital were searched to identify dogs that underwent PLDA of the thoracolumbar disks between January 1994 and September 2011 because of a previous episode of suspected or confirmed IVDH. Dogs were eligible for inclusion in the study if the medical record was complete and follow-up information was available for a minimum of 3 years after the procedure, unless a recurrence of IVDH was documented prior to this time. Dogs treated between 1994 and 2001 that were included in a previous study[19] reporting recurrence rate after PLDA but for which long-term (ie, ≥ 3 years) follow-up information was not available at the time of that study were eligible for inclusion in the present study.

Medical records review

Information on breed, sex, age, and body weight at the time of PLDA was obtained from the medical records of dogs included in the study, along with information on the number and severity of previous episodes of IVDH, the location of previous disk herniations (cervical vs thoracolumbar region of the vertebral column), whether previous episodes were managed surgically or medically, whether previous episodes were confirmed or suspected, and whether narrowed intervertebral disk spaces were present in the thoracolumbar portion of the vertebral column.

Information on results of neurologic examinations was reviewed, and a modified Frankel score[15,20–23] ranging from 0 to 5 was assigned for each previous episode of IVDH. Dogs with plegia and absent deep nociception were classified as grade 0, dogs with plegia and absent superficial nociception were classified as grade 1, dogs with plegia and intact nociception were classified as grade 2, dogs with nonambulatory paresis were classified as grade 3, dogs with ambulatory paresis were classified as grade 4, and dogs with spinal hyperesthesia only were classified as grade 5. In addition, previous episodes of IVDH were characterized as confirmed or suspected, and treatment (medical vs surgical) and recovery time were recorded.

Surgical procedure

Dogs were considered eligible to undergo PLDA if they had experienced a previous episode of suspected or confirmed IVDH; had completely recovered from the previous episode (ie, did not have any residual neurologic deficits or had only mild residual neurologic deficits such as proprioceptive deficits or ambulatory paresis that were static); had not received any pain medications, steroidal or nonsteroidal anti-inflammatory medications, or muscle relaxers within the preceding 2 weeks; and had not had any signs of pain during the preceding 2 weeks.

A preoperative CBC and serum biochemical panel were performed in all dogs undergoing PLDA. Dogs were anesthetized with an individualized anesthetic protocol developed by a board-certified veterinary anesthesiologist on the basis of each dog's specific needs and American Society of Anesthesiologists status. For dogs that underwent PLDA in 1994 through 2009, orthogonal radiographic projections of the thoracolumbar portion of the vertebral column were obtained after anesthesia was induced, and the procedure was performed in the radiology suite by a diplomate of the American College of Veterinary Radiologists. For dogs that underwent PLDA in 2010 or 2011, the procedure was performed in a surgical suite by a diplomate of the American College of Veterinary Surgeons or a surgical resident under direct guidance of a diplomate.

Dogs were positioned in right lateral recumbency for PLDA. Under fluoroscopic guidance, a 20-gauge, 2.5- or 3.5-inch spinal needle was inserted into the center of each disk space from T10-11 through L3-4 (1994 through April 2010) or L4-5 (May 2010 through 2011). After confirmation that all needles were centered in the disk space, the bevel of each needle was directed toward the greatest thickness of the nucleus pulposus. The needle stylet was removed, and a sterile, cleaved 320-µm low-quartz laser optical fiber[a] was inserted through each spinal needle so that approximately 1 to 2 mm of the fiber protruded from the end of the needle. A Ho:YAG laser[b] was then activated for 40 seconds at 2 W of power with a 10- or 15-Hz pulse repetition rate.[18,24] After each disk was treated, the needle was removed.

Postoperatively, dogs received an opioid injection of the clinician's choice. Oral pain medication was administered after dogs had recovered from anesthesia and was continued for 3 days. Often, an NSAID was the only pain medication prescribed, although some dogs also received tramadol (3 to 5 mg/kg [1.4 to 2.3 mg/lb], PO, q 8 h). Dogs were discharged the day after the procedure. Owners were instructed to confine their dogs to a crate at all times other than during leash walks for elimination purposes for 2 weeks.

For the present study, duration of the PLDA procedure and number of disk spaces ablated were recorded. Complications of PLDA were categorized as peracute (ie, occurring during the procedure), acute (ie, occurring ≤ 7 days after PLDA), or chronic (ie, occurring > 7 days after PLDA).

Owner questionnaire

For the present study, owners were contacted by telephone, email, or mail and asked to complete a survey regarding their dog's recovery and possible episodes of recurrence after PLDA. Specifically, owners were asked the following questions: immediately after PLDA, did you think your dog was improved, worse, or the same as before the procedure?; did your dog have any signs of pain or discomfort (eg, shaking, unwillingness to walk, vocalization, or hunched back) within the 2-week rest period after PLDA?; did your dog experience any episodes suggestive of a recurrence of IVDH (eg, wobbliness, pain, stumbling, inability to use its legs, dragging its legs, or walking on the tops of its paws) at any time after PLDA was performed?; if any signs suggestive of a recurrence were seen, what specific signs were seen?; if signs suggestive of a recurrence occurred, did they eventually resolve?; was additional surgery needed to resolve any clinical signs suggestive of a recurrence?; if clinical signs did resolve, how long did it take?; and on a scale from 1 to 10 (where 1 = completely dissatisfied and 10 = completely satisfied), how satisfied overall were you with the PLDA procedure?

Statistical analysis

A χ^2 test was used to compare rates of recurrence of IVDH (suspected or confirmed) between dogs for which episodes prior to PLDA were managed medically and dogs for which episodes prior to PLDA were managed surgically. The Fisher exact test was used to compare rates of confirmed recurrence of IVDH between the same groups and between dogs with a single episode versus multiple episodes of IVDH prior to PLDA. All analyses were performed with standard software.[c] Values with $P < 0.05$ were considered significant.

Results

Dogs

The review of medical records identified 393 dogs that underwent PLDA during the time frame of interest. Ninety dogs were excluded because the owner could not be contacted and the medical record could not be attained or was incomplete (n = 83), PLDA was performed < 2 weeks after a previous episode of suspected IVDH (3), or the dog died for unrelated reasons within 3 years after undergoing PLDA (4). The remaining 303 dogs were included in the study. Owners of 286 of the 303 dogs completed the survey questionnaire. For the remaining 17 dogs, long-term follow-up information was available from the medical record.

Two hundred ninety-four dogs were followed up for ≥ 3 years (range, 3 to 14 years). The remaining 9 dogs were followed up for < 3 years but were included in the study because they had an episode of suspected or confirmed IVDH within 3 years after undergoing PLDA. The median follow-up time for all 303 dogs was 6 years (IQR, 4.5 years). The median follow-up time for dogs for which an owner survey was completed (n = 286) was 6 years (IQR, 5 years). The median follow-up time for dogs for which an owner survey was completed or a thorough medical record was available (n = 296) was 6 years (IQR, 5 years). The median follow-up time for dogs in which a recurrence was documented earlier than 3 years after undergoing PLDA (n = 9) was 1 year (IQR, 0.44 years).

The study population included 187 (61.7%) Dachshunds, 30 (9.9%) mixed-breed dogs, 17 (5.6%) Shih Tzus, 14 (4.6%) Miniature Poodles, 8 (2.6%) Cocker Spaniels, 8 (2.6%) Pekingese, 5 (1.7%) Beagles, 4 (1.3%) Lhasa Apsos, 4 (1.3%) Pembroke Welsh Corgis, 3 (1.0%) Miniature Schnauzers, 3 (1.0%) Yorkshire Terriers, 2 (0.7%) Boston Terriers, 2 (0.7%) Jack Russell Terriers, 2 (0.7%) Bulldogs, 2 (0.7%) Pomeranians, 2 (0.7%) Bichon Frise, 2 (0.7%) Bassett Hounds, and 1 (0.3%) each of the following breeds: Chihuahua, Maltese, Lowchen, Pug, Cavalier King Charles Spaniel, Cardigan Welsh Corgi, French Bulldog, and Scottish Terrier. There were 149 (49.2%) spayed females, 113 (37.3%) castrated males, 29 (9.6%) sexually intact males, and 12 (4.0%) sexually intact females. Mean age at the time of PLDA was 5.7 years (SD, 2.35 years). Mean body weight at the time of PLDA was 7.6 kg (16.7 lb; SD, 3.23 kg [7.1 lb]).

Historical data

The 303 dogs had had a total of 449 episodes of IVDH prior to undergoing PLDA. Of these episodes, 228 (50.8%) were grade 5, 102 (22.7%) were grade 4, 80 (17.8%) were grade 3, 24 (5.3%) were grade 2, 8 (1.8%) were grade 1, and 7 (1.6%) were grade 0. One hundred fourteen (37.6%) dogs had had multiple episodes of confirmed or suspected IVDH prior to undergoing PLDA. Of those that experienced multiple episodes, 86 (75.4%) had 2 episodes, 22 (19.3%) had 3 episodes, and 6 (5.3%) had 4 episodes. Of the 303 dogs, 88 (29.0%) had undergone surgery for treatment of a previous episode of IVDH, 185 (61.1%) had been treated medically for a previous episode of IVDH, and 30 (9.9%) had received both medical and surgical treatment for previous episodes of IVDH.

Of the 449 previous episodes of IVDH, 300 (66.8%) had been managed medically without extensive diagnostic testing and were, therefore, considered suspected episodes of IVDH. The remaining 149 (33.2%) episodes were classified as confirmed episodes of IVDH on the basis of results of diagnostic testing and surgical findings. Of the 449 previous episodes of IVDH, 431 involved the thoracolumbar region and 18 involved the cervical region. All dogs that had an episode of suspected or confirmed cervical IVDH also had at least 1 episode of thoracolumbar IVDH at a different time.

Of the 303 dogs, 91 did not have adequate radiographic or CT images in the medical record to determine whether any of the disk spaces from T9-10 through L6-7 were narrowed. Of the remaining 212 dogs, 100 (47.2%) did not have any narrowed disk spaces, 69 (32.5%) had 1 narrowed disk space, 24 (11.3%) had 2 narrowed disk spaces, 9 (4.2%) had 3 narrowed disk spaces, 7 (3.3%) had 4 narrowed disk spaces, 2 (0.9%) had 6 narrowed disk spaces, and 1 (0.5%) had 8 narrowed disk spaces.

Surgical procedure

Time to complete the PLDA procedure was documented in the medical records of 297 dogs. For those dogs, mean time to perform the procedure was 58.3 minutes (SD, 19.3 minutes). Overall, 26 dogs had 8 spaces ablated, 249 dogs had 7 spaces ablated, 21 dogs had 6 spaces ablated, 5 dogs had 5 spaces ablated, 1 dog had 4 spaces ablated, and 1 dog had 3 spaces ablated. The PLDA procedure was performed by a board-certified radiologist in 239 dogs. In the remaining 64 dogs, the procedure was performed by a board-certified surgeon or a surgical resident under the direct supervision of a board-certified surgeon.

Complications

Peracute complications (ie, complications occurring during the procedure) were documented in 30 of the 303 (10.0%) dogs. The most common peracute complication was inability to insert a needle into the disk space because of rib superimposition (n = 3) or disk space narrowing (19). In 2 dogs, the needle was dislodged, and in another 2 dogs, a single space was not ablated because of mature mineralization in the spinal canal. Additional complications identified in 1 dog each were fusion of T10-11 through T13-L1 preventing needle insertion, mild hematoma formation at a single needle insertion site, and gastric distension prior to extubation. In 1 dog, a single space was not ablated, but a reason was not given in the medical record.

Acute complications (ie, complications occurring ≤ 7 days after PLDA) were documented in 26 (8.6%) dogs. The most common acute complications were ataxia after PLDA that continued for up to 7 days (n = 6), soreness along the back (4), mild ataxia immediately after the procedure that resolved in < 24 hours (3), greater pain than expected requiring administration of pain medication for 3 days longer than the standard protocol (2), and reluctance to move for 8 days after PLDA (2). Other acute complications documented in 1 dog each were yelping on 2 occasions at home while locked in a room, slow to get around at home, constipation, paraparesis the morning after surgery that resolved within 4 days, paraparesis the morning after surgery that resolved within 3 days, pain persisting for 5 days longer than expected, bruising over 1 needle insertion site, mild sensitivity during direct palpation of needle insertion sites, and ataxia that began immediately after the procedure but for which duration was not documented in the medical record.

Chronic complications (ie, complications occurring > 7 days after PLDA) were documented in 2 (0.7%) dogs and included signs of pain on palpation of the spinal region that required treatment with an NSAID (n = 1) and licking or chewing at the left hind paw 1 month after the procedure (1).

Owner survey

Owners of 286 dogs were successfully contacted. Two hundred seventy-five owners were contacted by telephone, 9 were contacted by email, and 2 were contacted by postal mail. Overall, 270 of the 286 (94.4%) owners reported that their dog was the same (109 [38.1%]) or improved (161 [56.3%]) immediately after PLDA. Ten (3.5%) owners believed their dog was worse immediately after PLDA, and 6 (2.1%) owners could not accurately comment on their perception. When owners were asked whether their dog appeared to be painful in the 2-week recovery period after PLDA, 23 (8.0%) responded that they believed their dog was painful, 257 (89.9%) responded that they did not believe their dog was painful, and 6 (2.1%) could not accurately comment. A total of 265 (92.7%) owners ranked their overall satisfaction with the PLDA procedure a 10 (238 [83.2%]), 9.5 (5 [1.8%]), or 9 (22 [7.7%]) on a scale from 1 (completely dissatisfied) to 10 (completely satisfied). The remaining owners assigned scores of 8.5 (3 [1.1%]), 8 (9 [3.2%]), 7.5 (1 [0.35%]), 7.0 (1 [0.35%]), 6 (2 [0.70%]), 5 (2 [0.70%]), 4 (1 [0.35%]), and 1 (2 [0.70%]).

Recurrence

Of the 303 dogs, 60 (19.8%) had a suspected or confirmed recurrence of IVDH. A total of 90 recurrent episodes were documented in these 60 dogs. Of these 90 recurrent episodes, 56 were grade 5, 20 were grade 4, 11 were grade 3, and 3 were grade 2. Overall, 35 of the 185 (18.9%) dogs that had been treated medically for an episode of IVDH prior to undergoing PLDA had a recurrence of IVDH following PLDA. Fourteen of the 35 (40%) had experienced multiple recurrent episodes prior to undergoing PLDA, with each episode managed medically. Twenty-one (60%) had experienced a single episode, and that episode had been managed medically. Twenty of the 88 (22.7%) dogs that had undergone surgery for treat-

ment of an episode of IVDH prior to undergoing PLDA experienced a recurrence of IVDH following PLDA. Two of the 20 (10%) had experienced multiple episodes prior to undergoing PLDA, with each episode managed surgically. Eighteen (90%) had experienced a single episode, and that episode had been managed surgically. The recurrence rate in dogs that had been medically managed prior to PLDA was not significantly (P = 0.464) different from the recurrence rate in dogs that had been surgically managed prior to PLDA. Five of the 30 (16.7%) dogs that received both medical and surgical treatment for multiple previous episodes of IVDH experienced a recurrence, which was not significantly different from the recurrence rate for dogs that were medically managed prior to undergoing PLDA (P = 0.769) or the recurrence rate for dogs that were surgically managed prior to undergoing PLDA (P = 0.483).

Although the overall recurrence rate of IVDH in the present study was 19.8% (60/303), this included dogs suspected, but not confirmed, to have recurrence. In addition, 19 of the 60 dogs that had been reported to experience a recurrence recovered completely from the episode in ≤ 3 days. Many of these dogs were not confined at all or were confined to a crate for only 24 hours and were subjected to owner interpretation regarding the presence of clinical signs or improvement of those signs.

Eleven of the 303 (3.6%) dogs had a recurrence of IVDH confirmed by means of CT or MRI and hemilaminectomy. These recurrences were classified as grade 5 (n = 2), grade 4 (4), or grade 3 (5). Eight of the 11 dogs with confirmed recurrences were Dachshunds, 1 was a mixed-breed dog, 1 was a Pekingese, and 1 was a Pembroke Welsh Corgi. Seven of the 185 (3.8%) dogs that had been treated medically for an episode of IVDH prior to undergoing PLDA experienced a confirmed recurrence, 3 of the 88 (3.4%) dogs that had been treated surgically for an episode of IVDH prior to undergoing PLDA experienced a confirmed recurrence, and 1 of the 30 (3.3%) dogs that had received both medical and surgical treatment for multiple previous episodes of IVDH experienced a confirmed recurrence. These percentages were not significantly different from each other.

Sixteen complications occurred among the 60 dogs with a suspected or confirmed recurrence of IVDH, and 3 of these 16 complications were related to the recurrence. One dog developed signs of acute pain after surgery that did not resolve, and a hemilaminectomy was subsequently performed. A second dog in which the T10-11 disk space was not ablated returned 3 years later because of grade 4 clinical signs that failed to resolve with medical management. A hemilaminectomy was performed at T10-11 because of spinal cord attenuation. The third dog had chronic signs of pain after PLDA that did not resolve with medical management; a T12-13 hemilaminectomy was performed 4 months later. Six of the 16 complications were possibly related to a suspected recurrence resulting from an inability to treat a specific intervertebral disk space at surgery.

Discussion

Percutaneous laser disk ablation is a prophylactic procedure that can possibly reduce the rate of recurrence of disk herniation in patients that have previously experienced an episode of suspected or confirmed IVDH. This procedure has historically been documented to result in a recurrence rate of 3.4%.[19] However, mean follow-up time for patients in that study was only 15 months (range, 1 to 85 months), and since publication of that study, Mayhew et al[12] suggested that a 3-year follow-up period was needed to accurately document rate of recurrence of IVDH. In addition, Brisson et al[13] reported that 21 of 24 recurrences occurred within 34 months after fenestration.[13] Therefore, we only included patients in the present study if they had been followed up for a minimum of 3 years, unless an episode of recurrence was documented prior to this time.

The overall rate of recurrence of IVDH in the present study was 19.8% (60/303); however, this included dogs suspected to have a recurrence but in which disk herniation was not confirmed. Also, owners of 19 of these 60 dogs reported that the dog had recovered completely in ≤ 3 days, and many of these dogs were not confined or were confined to a crate for a single night. Thus, we question whether some of these episodes were indeed recurrences and suggest that the overall recurrence rate of 19.8% should be interpreted cautiously.

Mayhew et al[12] retrospectively evaluated risk factors for recurrence of thoracolumbar IVDH in dogs that had not undergone prophylactic disk fenestration or PLDA and reported a rate of recurrence of suspected or confirmed disk herniation of 19.2%. However, they excluded any dog in which pain was the sole clinical sign (grade 5), thus eliminating any confusion with other disease processes that could result in pain. For the present study, excluding dogs in which pain was the sole clinical sign of a recurrence (ie, grade 5) would have reduced the rate of recurrence of suspected or confirmed disk herniation to 11.2% (34/303). Although the present study population cannot be directly compared with the population in the study by Mayhew et al[12] because of differences in management, the different recurrence rates provide at least some suggestion that PLDA may have been successful at reducing the recurrence rate. However, it is important to remember that pain is often the only clinical sign in dogs with IVDH. Therefore, excluding these dogs when calculating recurrence rate may be misleading, because IVDH may in fact be present.

Given findings in the present study, we rejected our hypothesis that the recurrence rate for dogs that underwent PLDA and for which long-term follow-up information was available would be similar to the 3.4% reported by Bartels et al[19] Although the rate of recurrence of confirmed IVDH in the present study

was 3.6% (11/303), this included dogs with signs ranging from pain alone to nonambulatory paresis. In contrast, the 3.4% recurrence rate reported by Bartels et al[19] included only those dogs that had nonambulatory paresis or a worsening of their neurologic signs.

In human medicine, PLDA was originally developed to reduce the incidence of disk herniation[1–3]; however, an additional reported benefit of PLDA was a reduction in intradiskal pressure that resulted in persistent or repeated back pain. This reduction in intradiskal pressure was noted as a secondary effect of reducing the volume of the nucleus pulposus subsequent to ablation.[6,7,9–11] A similar effect of PLDA may also be occurring in dogs. For example, 56.3% (161/286) of owners reported that their dog was improved immediately after PLDA, with many owners reporting that their dog wanted to jump and run immediately and that confinement for 2 weeks after PLDA was extremely difficult. This was often reported as a drastic difference in the dog's demeanor. Of course, owners who seek to have PLDA performed prophylactically may be biased, suggesting that subjective observations such as these should be viewed with caution. However, owners were often excited to describe the change in attitude of their dog after PLDA, not just in the immediate postoperative period but indefinitely thereafter. Although subjective, these findings may suggest that dogs have subclinical back pain more often than has been thought.

In the present study, the recurrence rate following PLDA was not significantly different between dogs that had been treated medically for previous episodes of IVDH versus dogs that had been treated surgically. Likewise, recurrence rate did not differ between dogs that were solely medically managed or solely surgically managed for previous episodes of IVDH prior to undergoing PLDA and dogs that were medically and surgically managed for multiple previous episodes. These findings suggested that previous treatment does not play a role in the success of PLDA. Notably, in dogs that were medically managed for episodes of IVDH prior to undergoing PLDA, the diagnosis was not confirmed and only suspected. However, these dogs had been evaluated by a veterinarian and had clinical findings, including signs of pain in response to palpation of the vertebral column, highly suggestive of IVDH. Although other disease processes could not be ruled out, if signs in these dogs had been a result of infection, an inflammatory process, or neoplasia, we would have expected the signs to progress.

One advantage of PLDA is that it is minimally invasive, with potentially shorter anesthetic times and lower morbidity rates, compared with disk fenestration. Mean procedure time in the present study was 58.3 minutes (SD, 19.3 minutes). However, there appears to be a steep learning curve, with surgical time decreasing with practice and repetition. Currently, the procedure can be performed in approximately 25 minutes by one of the authors (DRD).

In people, identification of disk mineralization at the time of decompressive surgery has been associated with a higher likelihood of recurrence.[7] Although the effects of disk mineralization were not specifically evaluated in the present study, it is possible that mineralization could have played a role in recurrence of clinical signs after PLDA. Energy density (fluency) and power values used to perform PLDA were initially derived from unpublished in vitro research in which clear gelatin mixed with a pulverized calcium carbonate powder and contained in a culture plate was used to mimic a calcified disk. A spectrum of settings was then tested on cadaver disks to determine optimum laser settings without resulting in collateral damage outside the targeted nucleus pulposus.[24] The current laser settings (2 W of power with a 10-Hz pulse repetition rate) were chosen to provide adequate photothermal and photoablative effects to the nucleus pulposus while minimizing damage to the annulus and vertebral endplates. The original settings (2 W of power with a 15-Hz pulse repetition rate) yielded an energy of 0.1 J per pulse at each disk, delivering a total energy of 84 J. However, the laser manufacturer has changed the unit so that a pulse repetition rate of 15 Hz can no longer be obtained. Current settings (2 W of power with a 10-Hz repetition rate) yield 0.2 J per pulse at each disk, for a total delivery of 80 J. Thus, the current setting provides slightly more energy per pulse, compared with the original settings, but the total energy delivered to each disk is essentially the same. The Ho:YAG laser was originally chosen to perform PLDA because of its strong absorption by water.[8] However, substantial chondroid metaplasia in the nucleus pulposus may reduce its photothermal and photoablative effects. A recent study[25] examined the value of single-fiber reflectance spectroscopy as a means to determine the degree of nuclear calcification prior to PLDA, with the hope that results could be used to adjust laser settings to improve ablation of calcified disks.

A particular concern with PLDA is the inability to insert needles into some narrow or fibrotic disk spaces, preventing ablation of the nucleus pulposus. The most common peracute complication in the present study was inability to insert a needle into the disk space because of disk space narrowing. This occurred in 19 dogs, and in 6 of these 19 dogs, a suspected recurrence resulting from an inability to treat a specific intervertebral disk space at surgery was reported. Thus, inability to ablate a disk because of disk space narrowing may result in a higher likelihood of future disk herniation, although the true risk could not be accurately determined for our population. Nevertheless, disk space narrowing should be considered a limitation to performing PLDA.

Although most owners reported that their dog was improved or the same immediately after PLDA, 3.5% (10/286) of owners believed their dog was worse clinically. Specifically, 7 owners reported that their dog was painful, with the painful episode reported to have resolved within 2 or 3 days (n = 6) or 10 days (1). Two owners reported that their dog was ataxic,

and 1 owner reported that the dog would drag its legs when trying to walk. Recurrence was identified in 1 dog that was documented to be worse immediately after PLDA; this dog was painful after PLDA and was found to have a grade 5 recurrence. The goal of any prophylactic procedure is to successfully perform the procedure without causing any negative effects. The reality that PLDA can result in postoperative pain or ataxia must be discussed with owners, especially if this procedure is considered in patients that have never experienced an episode of IVDH.

Currently, we perform PLDA only on the disk spaces from T10-11 through L4-5. These disk spaces have been previously documented to have the highest incidence of disk herniation.[17] To date, PLDA of the cervical disk spaces has not been attempted in a large number of patients; however, we believe the procedure could be used in this location as well. In the few dogs in which cervical PLDA was performed at our hospital, only C2-3, C3-4, and C4-5 could be consistently ablated owing to the presence of the scapula preventing needle placement caudal to these sites.

Most often, PLDA is performed on dogs that have had a previous episode of confirmed or suspected IVDH and have completely recovered. To date, 5 dogs have undergone PLDA at our hospital as a true prophylactic procedure at the request of the owner. Although PLDA does have a risk of complications, the risk appears to be low. Thus, prophylactic PLDA in dogs that have never had an episode of IVDH may become more common. However, owners must be made aware that their dogs may never experience an episode of disk herniation during their lifetime without PLDA. In addition, further research is needed to determine whether PLDA is effective as a truly prophylactic procedure.

There were limitations inherent to the present study. As with any retrospective study, interpreting the medical records was sometimes difficult. In addition, evaluators were not blinded to the treatment and no control group was included. Also, 83 dogs representing 21.1% (83/393) of the PLDA cases during the study period were excluded because the owner could not be contacted and the medical record was not complete. Inclusion of these cases could potentially have altered the recurrence rate identified in this population of dogs. Additional limitations included the fact that multiple clinicians performed the procedure and the study consisted of dogs treated over a long period, which could have affected complication or recurrence rates. Likewise, recurrence of disk herniation following PLDA was largely based on owner assessments. When possible, we reviewed the medical record to verify owner-provided information; however, there are inherent difficulties in accurately determining outcomes from medical records. Finally, the diagnosis of IVDH was not definitive in many dogs either before or after PLDA, which may have led to inclusion of dogs without IVDH or to miscalculation of the recurrence rate.

In conclusion, results of the present study suggested that PLDA was a relatively safe, minimally invasive procedure that appeared to decrease the rate of recurrence of disk herniation in dogs that underwent the procedure because of a previous episode of suspected or confirmed IVDH.

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Footnotes

a. 320-µm low-quartz laser optical fiber (model H320R/part 9400-0310), 320-µm-diameter silica core fiber jacketed with ethylene tetrafluoroethylene, SMA 905 connector, New Star Lasers, Roseville, Calif.

b. Ho:YAG laser (model NS 1500; wavelength, 2.1 µm; 12 W), New Star Lasers, Roseville, Calif.

c. SAS, version 9.4, SAS Institute, Cary, NC.

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From this month's *AJVR*

Computed tomographic anatomy of the heads of blue-and-gold macaws (*Ara ararauna*), African grey parrots (*Psittacus erithacus*), and monk parakeets (*Myiopsitta monachus*)

Irene A. Veladiano et al

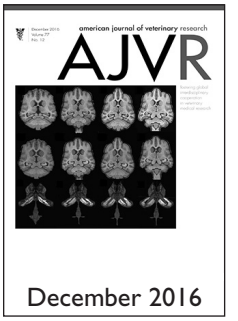
OBJECTIVE
To create an atlas of the normal CT anatomy of the head of blue-and-gold macaws (*Ara ararauna*), African grey parrots (*Psittacus erithacus*), and monk parakeets (*Myiopsitta monachus*).

ANIMALS
3 blue-and-gold macaws, 5 African grey parrots, and 6 monk parakeets and cadavers of 4 adult blue-and-gold macaws, 4 adult African grey parrots, and 7 monk parakeets.

PROCEDURES
Contrast-enhanced CT imaging of the head of the live birds was performed with a 4-multidetector-row CT scanner. Cadaveric specimens were stored at –20°C until completely frozen, and each head was then sliced at 5-mm intervals to create reference cross sections. Frozen cross sections were cleaned with water and photographed on both sides. Anatomic structures within each head were identified with the aid of the available literature, labeled first on anatomic photographs, and then matched to and labeled on corresponding CT images. The best CT reconstruction filter, window width, and window level for obtaining diagnostic images of each structure were also identified.

RESULTS
Most of the clinically relevant structures of the head were identified in both the cross-sectional photographs and corresponding CT images. Optimal visibility of the bony structures was achieved via CT with a standard soft tissue filter and pulmonary window. The use of contrast medium allowed a thorough evaluation of the soft tissues.

CONCLUSIONS AND CLINICAL RELEVANCE
The labeled CT images and photographs of anatomic structures of the heads of common pet parrot species created in this study may be useful as an atlas to aid interpretation of images obtained with any imaging modality. (*Am J Vet Res* 2016;77:1346–1356)



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