Transarticular Facet Screw Stabilization and Dorsal Laminectomy in 26 Dogs with Degenerative Lumbosacral Stenosis with Instability

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Objective: To describe outcome after transarticular facet screw stabilization and dorsal laminectomy for treatment of dynamic degenerative lumbosacral stenosis (DLS) in 26 dogs.
Study Design: Retrospective case series.
Animals: Dogs (n = 26) with dynamic DLS.
Methods: Medical records (2004–2009) of dogs treated with transarticular facet screw stabilization and dorsal laminectomy were reviewed. Dogs (n = 26) were available for immediate postoperative follow-up, 21 dogs at 6 weeks, and 15 at greater than 6 months. Dogs were evaluated by radiographic assessment and owner questionnaire. Lumbosacral (LS) intervertebral disc (IVD) spaces were measured on pre and postoperative 6-week and 6-month radiographs.
Results: In 23 dogs, improvement in clinical signs occurred within 7 days of surgery. Overall postsurgical complication rate directly related to the surgical procedure was 15.4%. LS IVD space measurements taken immediately postoperatively, at 6 weeks, and $\geq$ 6 months were all significantly increased compared with preoperative measurements. All working dogs (4) returned to full work within 14 months. Most owners (85%) reported their dog was ambulating normally at 6 months with no perceptible lameness during normal activity. All owners perceived their dog's ability to walk, run, and jump after surgery to be improved.
Conclusions: Transarticular facet screw stabilization and dorsal laminectomy maintains distraction of the LS IVD space for medium-to-large breed dogs with dynamic DLS with a high degree of owner satisfaction, and is comparable to other reported surgical techniques for DLS.

There is an array of clinical conditions of the canine lumbosacral (LS) region are most accurately defined by *cauda equina syndrome'* (CES).[1,2] The cauda equina is the terminal spinal cord, including the 7th lumbar (L7), sacral, and caudal spinal cord segments and their nerve roots.[1–3] CES is a complex of neurologic sign that can arise secondary to compression, entrapment, inflammation, and vascular compromise to the nerve roots that form the cauda equina.[1] Degenerative lumbosacral stenosis (DLS) is the most common manifestation of CES and compromise to the soft tissue support structures is fundamental in the progression of this disease with development of dynamic instability.[1,5] Transfer of mechanical forces through the canine lumbar spine is greatest at the LS junction, supporting the hypothesis that not only is this intervertebral joint inherently dynamic, but abnormal and altered motion may precipitate anatomic laxity and degenerative changes of the soft tissue support structures.[6–8]

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DLS most commonly occurs in middle age medium-to-large breed dogs, with an average age of 7 years. Males are reported 2:1–5:1 times more commonly than females.[1] Dogs most commonly present for unilateral or bilateral pelvic limb lameness, caudal lumbar pain, mild or intermittent placing deficits, and ataxia.[1,4] LS pain can manifest as reluctance or difficulty to exercise, rise and sit, climb stairs, or jump and clinical signs are exacerbated by exercise and work. In dogs with severe chronic DLS, clinical signs can include marked ataxia, depressed pelvic limb myotatic, ischiatic and withdrawal reflexes, patella pseudo-hyperreflexia, pelvic limb plantar stance, muscle atrophy, and bladder or anal dysfunction causing incontinence.[9]

Clinical suspicion of DLS is generated from signalment, history, clinical examination, and survey radiography. Advanced diagnostic imaging, including contrast radiography (myelography, epidurography, discography), computed tomography (CT), and magnetic resonance imaging (MRI), are used to confirm the diagnosis.[5,11,12] Radiographic changes at the LS junction are not uncommon in dogs without clinical signs, likewise dogs presenting with caudal lumbar pain and neurologic deficits, may have minimal or no radiographic findings; making interpretation sometimes challenging.[13] CT and MRI allows precise identification of changes in the LS IVD, at the LS articular facet joints, in the intervertebral foramina and within the vertebral canal and lateral recesses of the vertebral body. Three-dimensional reconstruction further allows identification of articular facet joint subluxation, representing dynamic instability, and quantitative geometrical analysis. To date, the ability of diagnostic imaging to definitively diagnose and precisely quantify the presence and extent of LS instability in the preoperative stage appears to remain limited.

Medical management such as anti-inflammatory pharmaceuticals and restricted exercise can result in partial or temporary resolution of clinical signs of DLS.[1] Surgical treatment is usually indicated when medical management fails to resolve clinical signs, in dogs with persistent pain or neurologic deficits, when dynamic instability of the LS junction is suspected or diagnosed, and for working dogs that are expected to return to work. Dorsal laminectomy, with or without facetectomy, fenestration, or partial discectomy, is the most common surgical procedure reported for DLS.[15] Postoperative success rates have been reported ranging from 41 to 93% with follow-up times ranging from 2 to 82 months, in both qualitative and quantitative investigations.[9,15–22]

When LS instability is a suspected component of DLS, dorsal laminectomy alone is not sufficient and a method of distraction and stabilization is indicated.[2,15,23,24] For dogs and people, the presence of LS instability has a less favorable prognosis compared with cases without instability.[24,25] Various surgical techniques are described to achieve distraction and stabilization of the canine LS joint including transarticular facet screw stabilization, transiliac pins +/− dorsal spinous process plates, pedicle screw/rod fixation, screw, and polymethylmethacrylate construct bridge, external skeletal fixator, and dorsal spinous process plates.[2,15,24]

Our purpose was to determine the long-term radiographic and owner perceived outcome in 26 dogs diagnosed with dynamic DLS and treated with transarticular facet screw stabilization and dorsal laminectomy.

MATERIALS AND METHODS

Dogs

Clinical records (2004–2009) of 26 dogs consecutively diagnosed and treated for dynamic DLS were reviewed. Recorded information included signalment; nature, and duration of clinical signs; neurologic and orthopedic examination findings on admission; plain radiography, and advanced imaging (CT or myelography) findings; surgical findings; postoperative radiographs and clinical assessment, and reported complications. Diagnosis of dynamic DLS was based on clinical examination, plain radiography, myelography (n = 2) or CT (n = 24), and intraoperative findings. Unrelated history and concurrent orthopedic or medical problems were recorded.

Preoperative Clinical Examination

A complete orthopedic and neurologic examination was performed on each dog. Presence of pelvic limb lameness (unilateral or bilateral); pelvic limb ataxia (unilateral or bilateral); pelvic limb placing responses (unilateral or bilateral); reluctance to jump; short-stepping gait; pain on dorsal elevation of the tail; pain on direct dorsal LS palpation; abnormalities in pelvic limb spinal reflexes (depressed or exaggerated); urinary and fecal incontinence; and pelvic limb muscle atrophy was recorded.

Diagnostic Imaging

Survey radiographs of the LS region were taken in all dogs under sedation. CT of the LS region was recommended for all dogs and was performed in 24 dogs. Dogs were sedated and positioned in dorsal recumbency with extended coxofemoral joints. A 64-slice helical CT scanner (General Electrical Lightspeed, Milwaukee, WI) with exposure settings of 125 kV, 250 mA with 12.5 seconds scanning time was used. Contiguous transverse 0.625 mm thick CT slices were obtained from the mid lumbar region to the caudal sacral vertebrae. Multiplanar axial, sagittal, and coronal images were reconstructed from the transverse images and all images were evaluated in both bone and soft tissue window settings. In the other 2 dogs, lumbar myelography was performed.

Sedation, Anesthesia, and Analgesia

Radiographs and CT images were performed under sedation with medetomidine (0.02 mg/kg intravenously [IV]) and butorphanol (0.1 mg/kg IV). Atropine (0.022 mg/kg) and morphine (0.4 mg/kg) were administered subcutaneously before induction of anesthesia. Anesthesia was induced with diazepam (0.25 mg/mL IV) and propofol (4 mg/kg IV) and maintained with isoflurane in oxygen and nitrous oxide. Morphine (0.5 mg/kg subcutaneously) or buprenorphine (0.01 mg/kg subcutaneously) were administered for postoperative analgesia as needed for 24–48 hours. Carprofen (2 mg/kg, twice daily, orally) was administered for 7–10 days after surgery.

Surgical Technique

The transarticular facet screw stabilization technique used has been described[14] and formed part of the American College of Veterinary Surgeons Laboratory, Denver CO, 2004.

Cefazolin (22 mg/kg IV) was administered after induction. The skin at the surgical site was aseptically prepared and the dog was positioned in ventral recumbency with both pelvic limbs flexed in a neutral, sitting position. A sand bag was placed under the caudal aspect of the abdomen to facilitate widening of the LS interarcuate space. The skin was incised from the spinous process of L5 and extended to the caudal margin of the sacral spinous process on the dorsal midline. The superficial and deep lumbodorsal fascia was incised. The epaxial musculature was elevated from the spinous processes and sharp dissection was used to remove the muscular attachments to the articular processes of L7–S1. The facet joint capsule was opened to facilitate assessment of joint subluxation.

Dorsal laminectomy was performed across the caudal aspect of L7 and the cranial aspect of the sacrum, and the ligamentum flavum was removed to expose the cauda equina. The dorsal spinous process of L7 was partially preserved. The laminectomy used was narrower than reported for decompressive laminectomy, in an attempt to maintain base strength of the articular facets. Protruded annulus fibrosis was resected, if present. Collapse of the dorsal LS articulation was assessed by noting the extent of cranioventral tilting (telescoping) of the sacrum; the relative positions of L7 and S1 dorsal lamina; and the amount of exposed articular cartilage on the sacral facet. Articular facet subluxation was reduced in a cranial-caudal direction using laminectomy spreaders. Articular cartilage on both surfaces of the facet joint was removed using a scalpel blade or a small bur. Cortical bone screws (3.5 mm) were placed at a 30–45° angle through the center of the L7 facet in a craniodorsal to caudoventral direction to traverse the L7–S1 articular facets into the body of the sacrum to thus maintain the distracted position. Cancellous bone graft obtained from an ilial wing was placed into and around the LS facet joints.

An autogenous fat graft, harvested from the subcutis, was placed over the dorsal laminectomy site. The muscular layer was closed using 3 metric polydioxanone in a simple continuous pattern; the subcutaneous layer was closed using 2 metric poliglecaprone-25 in a simple continuous pattern; the skin was closed using 2 metric polyamide in a simple interrupted pattern. Dogs were restricted to cage rest with minimal leash walking for the first 6 weeks postoperatively, with gradual return to normal exercise over the next 4–6 weeks.

Postoperative Assessment

Dogs were returned for evaluation at 6 weeks. Clinical examination and postsurgical complications were recorded. Dogs were sedated and radiographs obtained to assess healing of the surgical site. Presence of LS spondylosis deformans (partial or complete), mineralization of the LS disc, and implant failure (migration, breakage/bending or bony lucency) were all recorded. The LS disc space was measured to the nearest 0.5 mm.

Dogs returned for re-evaluation ≥ 6 months for radiographs and completion of an owner questionnaire. Dogs that did not have radiographs taken at ≥ 6 months were excluded from long-term analysis. Questionnaires were provided to the owners of the dogs presented for 6-month follow-up. Questions asked addressed the nature, intensity and duration of exercise, frequency of perceived pain, frequency and type of anti-inflammatory medications or chondroprotective agents, and owner satisfaction of the procedure.

Data Analysis

Lumbosacral disc space measurement was performed with a standardized technique, by 1 author (EH), using calipers and a line ruler (Fig 1): The caudodorsal (A) and caudoventral (A`) points of L7 and the craniodorsal (B) and cranioventral (B`) points of sacrum were determined and labeled on the lateral radiograph. The mid-points, in a horizontal plane, between the 2 dorsal and 2 ventral points were determined, which were in turn used to determine the mid-point in a vertical plane. The latter point was deemed the center of the LS intervertebral space and therefore the allocated position at which measurements were taken (Fig 1, X–Y). A 1-tailed paired Student's t-test was performed on the LS disc space measurements (mm) using software (Excel^{TM}, Microsoft Corp, Santa Rosa, CA) to compare the preoperative LS intervertebral disc (IVD) spaces to the immediate postoperative, 6-week and 6-month postoperative measurements. Significance was set at $P < .05$.

RESULTS

Signalment and Initial Clinical Exam

Twenty-six dogs (mean age, 6.68 years; range, 2–11 years) were initially included. Sixteen dogs (61.5%) were male (3 entire, 13 neutered) and 10 (38.5%) were spayed females. Breeds were German Shepherd (6), Labrador (5), New Zealand Huntaway Cattle/Sheep Dog (2), Border Collie (2), Dalmatian (2), Cross-bred (2), and 7 other breeds (Boxer, Staffordshire Terrier, Doberman, Airedale Terrier, Flat-Coated Retriever, American Bulldog, Miniature Schnauzer) represented by 1 dog each. Dogs were classified as working (n = 4) or nonworking (22). Four dogs (15.4%) were working animals, including: police, farm (2), and aviation security. Before surgery, all dogs had been trialed with medical management for an average duration of 4.2 months (range, 0.25–24 months) including nonsteroidal anti-inflammatory drug therapy and complete or partial exercise restriction. Historical findings at the time of referral included, exercise intolerance (84.6%), reluctance to jump (73.1%), and urinary incontinence (7.7%).

On clinical examination, all dogs (100%) had a pain response to dorsal pressure on the LS junction. Other findings included pelvic limb lameness (38.5%), short-stepping

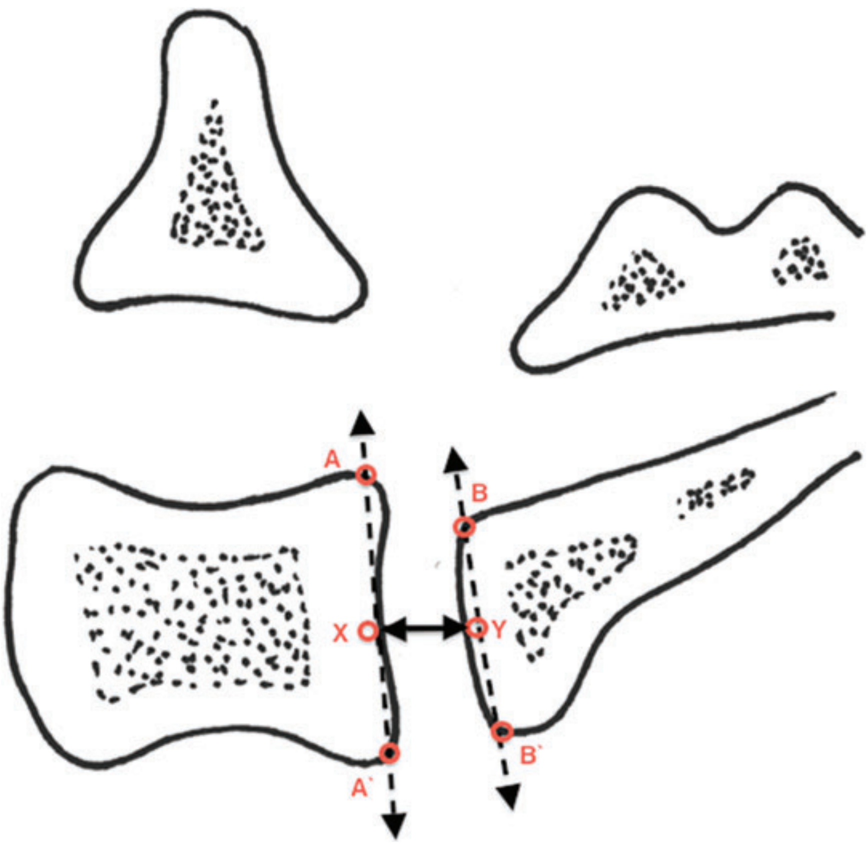

Figure 1 Line drawing of the canine LS junction illustrating the methodology used to measure the LS IVD space at the determined center point. A, A` = caudodorsal and caudoventral points of the seventh lumbar vertebra; B, B` = craniodorsal and cranioventral points of sacrum; X–Y position of measured LS intervertebral space.

pelvic limb gait (50%), pelvic limb ataxia (23.1%), pelvic limb muscle atrophy (3.8%), positive pain response to dorsal elevation of the tail (65.4%), pelvic limb placing deficits (61.5%), and abnormalities in pelvic limb spinal reflexes (patella, ischiatic, withdrawal) (26.9%).

Surgical Procedure and Immediate Postoperative Complications

Eighteen dogs (69%) had intraoperative evidence of dorsal protrusion of the annulus fibrosus of the LS disc. All dogs had evidence of LS instability, indicated by subluxation (over-riding) of the LS facet joints and cranioventral displacement of the sacrum. The distracted LS junction was stabilized using 3.5 mm cortical screws in all dogs.

Improvements in clinical signs occurred within 7 days of surgery in 23 dogs. Three dogs had poor outcomes in the 7-day postoperative period and were excluded from further analysis. In 1 dog, the dorsal laminectomy revealed a large soft tissue mass in the LS space that extended into the L7 canal, samples were taken, and diagnosed on histopathology as degenerate cartilage and bone, with acute inflammatory infiltrates, granulation tissue, and fibrosis. Surgical stabilization in this dog was uneventful; however, there was no clinical improvement and the dog was euthanatized at owner's request 5 days after surgery. One dog died 13 hours after surgery with presumed cardiac arrest secondary to pulmonary thromboembolism. One dog fell 5 days after surgery and became acutely nonambulatory. Radiographs revealed a narrowed LS space and surgical exploration revealed bilateral articular facet fractures with ventral displacement of the cranial sacrum. The LS joint was stabilized using 4 bone screws and polymethylmethacrylate. Recovery in this dog was uneventful.

Short-Term Outcome

Preoperative radiographic findings at the LS junction included partial ventral spondylosis deformans (11 dogs); complete ventral spondylosis deformans (6); mineralization of LS IVD (6); and narrowing of the LS IVD disk space (Fig 2). The mean preoperative LS IVD space measured 3.0 mm. CT (n = 24) demonstrated protrusion of annulus into the spinal canal in 16 dogs (61.5%) and loss of epidural fat in 10 dogs (41%). On myelography (n = 2), marked attenuation of the distal thecal sac was identified from L5 to the caudal aspect of the LS junction. The mean postoperative LS IVD space measured 4.0 mm (Fig 3). There

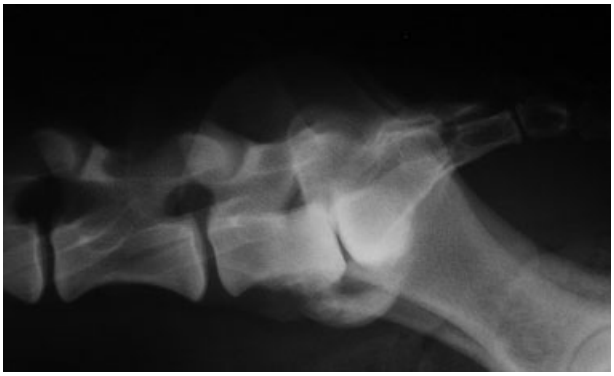

Figure 2 Lateral preoperative radiograph of study dog diagnosed with DLS and suspected instability. Note, the narrowed LS disc space and the presence of bridging ventral spondylosis deformans.

Figure 3 Lateral postoperative radiograph of study dog treated with transfacet screw stabilization and dorsal laminectomy.

was a statistically significant increase in the LS IVD space between pre and postoperative measurements ($P < .00004$).

Twenty one dogs were re-evaluated radiographically at 6 weeks. All dogs had radiographic evidence of new bone production around the LS facet joints and LS IVD space size stability. Seventeen dogs (81%) had radiographic evidence of stable surgical implants. Three dogs (14.2%) had radiographic evidence of unilateral cortical screw breakage; 1 (4.8%) had radiographic evidence of bilateral cortical screw breakage. Dogs with broken screws had recovered well from surgery and there was no evidence of associated clinical signs. The mean 6-week LS IVD space measurement was 3.5 mm. There was a statistically significant increase in the disc space between the pre and 6-week postoperative measurements ($P < .006$). At 14 and 17 weeks after surgery, 2 dogs became exercise intolerant and were reluctant to jump and sit. On re-examination, moderate pain was elicited on dorsal palpation of the LS junction and both dogs had radiographic evidence of craniodorsal migration of the cortical bone screws. The screws were removed in both dogs and the clinical signs resolved. One of these dogs was available for long term follow-up and the other was lost to follow-up.

Figure 4 Lateral (A) and ventrodorsal (B) postoperative radiographs of a working dog at and 42 months after transfacet screw stabilization and dorsal laminectomy. Note: On the ventrodorsal radiograph, the right cortical screw appears to purchase the sacroiliac joint. This is of unknown clinical significance and the dog had no associated clinical signs.

Long-Term Radiographic Outcome

Fifteen (65%) of 23 dogs were available for long-term radiographic follow-up at an average postoperative interval of 13.9 months (range, 6.1–42 months). Two dogs were euthanatized for unrelated reasons after the 6-week follow-up examination but before 6 months had elapsed after surgery. Six other owners were contacted but declined additional sedation and radiography for their dogs. Two dogs had radiographic assessment but the owners did not complete an owner questionnaire.

All 15 dogs radiographed had evidence of bone healing and stabilization of the distracted LS IVD space. Twelve (80%) had radiographic evidence of stable surgical implants. Two of the 4 dogs previously identified with unilateral screw breakage at 6 weeks were available for long-term assessment, with relatively unchanged radiographic findings. One of the dogs that had screw removal at 17 weeks was available for long-term follow-up and had radiographic evidence of bone healing and stabilization of the distracted LS IVD space. The mean long-term postoperative LS IVD space measurement was 3.5 mm. There was a statistically significant increase in the disc space between preoperative and 6-month postoperative measurements ($P < .05$). Three of the 4 dogs classified as working dogs were available for long-term follow-up and were all included in the 12 dogs with radiographic evidence of stable surgical implants (Fig 4). Two returned to full work between 6 and 12 months after surgery, 1 dog returned to full work at 14 months after surgery. One of the 2 dogs admitted with urinary incontinence preoperatively was available for long-term follow up, and this dog had resolution of clinical signs after surgery.

Owner Evaluation

Thirteen questionnaires were returned and available for analysis. Twelve (92%) owners reported their dog had normal ability to walk, with no perceptible lameness during normal activity. Eleven (85%) owners indicated that their dog had normal ability to run and jump with no perceptible lameness at any time whereas 2 (15%) owners reported their dog to have some perceptible lameness or pain after running and jumping, or after a long rest, but was normal most of the time. All owners perceived their dog's ability to walk, run, and jump after surgery to be improved. Two (15%) owners reported their dog to never or infrequently (0–1 times monthly) show signs of pain related to DLS or the surgery. At 6 months, all 4 working dogs had no perceptible pain at any time and could jump to the same height before the onset of clinical signs and surgery. Only 3 (23%) owners were administering nonsteroidal anti-inflammatory medications occasionally (2–3 times monthly) and 2 of these owners were using the medication for unrelated orthopedic problems. Three owners were supplementing their dogs with chondroprotective agents. All owners were very satisfied with the surgical procedure and the clinical outcome. Twelve (92%) owners indicated that they would have this procedure performed on another dog with the same condition and the remaining 1 was "undecided" for financial reasons.

DISCUSSION

Our results suggest that transarticular facet screw stabilization with dorsal laminectomy is an effective surgical treatment for dogs diagnosed with DLS with suspected or diagnosed LS instability. The retained stability of the LS IVD space by at least 6 months after transarticular facet screw stabilization with dorsal laminectomy surgery and the high degree of owner satisfaction supports this technique as an effective surgical method of providing dorsal decompression and eliminating dynamic compression at the LS IVD space. Major complications directly related to the surgical procedure resulting in euthanasia or additional surgery occurred in 4 (15.4%) dogs. Breakage of screws was identified in 4 dogs but this was not associated with clinical signs and no additional treatment was required. Owner satisfaction (92%) was excellent and compared favorably with those reported for other surgical techniques for treatment of DLS. Transarticular facet screw stabilization with dorsal laminectomy does not require specialized surgical equipment beyond that available for routine orthopedic and spinal surgery.

Little has been published on the precise recognition, diagnosis, or treatment of anatomic instability at the LS region in dogs. Several studies of outcomes in dogs treated with dorsal laminectomy without stabilization, introduce the idea and potential influence that instability at the LS junction may have. A small number of reports on DLS have reported surgical or diagnostic imaging evidence to support the presence of instability, including cranioventral tilting of S1 in relation to L7 (described as "telescoping") and the degeneration and herniation of the LS IVD.[18,24] In a retrospective study of dogs treated with dorsal laminectomy for DLS alone, 52% of dogs had telescoping of the sacrum relative to L7.[18] None of these dogs had surgical stabilization and an overall postoperative improvement was reported in 79% dogs. Residual problems after surgery and recurrence of clinical signs may result from several causes. Inherent or intermittent and undiagnosed LS instability present in some dogs with DLS may potentially require distraction and stabilization at the LS junction. It is possible to hypothesize that the absence of surgical distraction and stabilization at the time of surgery may be a contributing factor for postsurgical success rates as low as 41%. Although dorsal laminectomy in dogs is not believed to reduce segmental stability in a clinically important manner, several human studies have demonstrated that dorsal laminectomy and discectomy may further destabilize the LS junction and accelerate the development of degenerative changes, instability, and associated pain.[25,27] This suggests the importance and need for LS surgical stabilization after decompressive surgery. Likewise, untreated foraminal stenosis is an important cause of "failed back surgery syndrome" in people, therefore vertebral and foraminal decompression for the treatment of caudal lumbar stenosis is often combined with distraction and fusion of vertebral segments.[26] To our knowledge, investigation into the prevalence, diagnosis, and need for, or influence of, stabilization, at the LS junction has not been reported in the veterinary literature.

There is limited published data that has reviewed outcomes of surgical techniques for the treatment of dynamic instability at the LS junction and to our knowledge, no studies that have compared surgical techniques.[14,15,24] Critical analysis of surgical techniques and outcomes in a retrospective manner remains inherently challenging not only from the variation in surgical technique; but the varied population, methodology and chronology of postoperative evaluation and follow-up time; and diagnostic imaging modalities. The current choice of surgical technique thus appears to depend on surgeon preference and individual case selection.

Transarticular facet screw stabilization was first suggested by Oliver et al and is based on the proposed similarity between CES and caudal cervical spondylopathy.[27] Transvertebral distraction opens the vertebral canal and intervertebral foramen to relieve compressive forces acting on the cauda equina, the 7th lumbar nerve root, and associated vascular and connective tissue structures. Dorsal laminectomy relieves dorsal compression of the cauda equina and allows surgical access for discectomy.[14,27] Compared with traditional decompressive laminectomy, transarticular facet screw stabilization uses a narrow dorsal laminectomy, in an attempt to maintain the strength at the base of the articular facets. Transarticular facet screw placement acts to widen and maintain the foraminal and vertebral apertures and to stabilize the LS junction by eliminating dynamic compression.[2,14]

Our findings regarding age, breed, sex, history, and clinical signs in dogs with DLS were similar to previous reports: Middle-aged, medium-to-large breed male dogs were most commonly affected, with German Shepherd Dogs and Labrador Retrievers making up 42% of dogs.[9,12–15] Reluctance to jump (73%) and short-stepping gait (50%) were the most frequently reported clinical signs by owners. All dogs had a clinical history of attempted medical management,

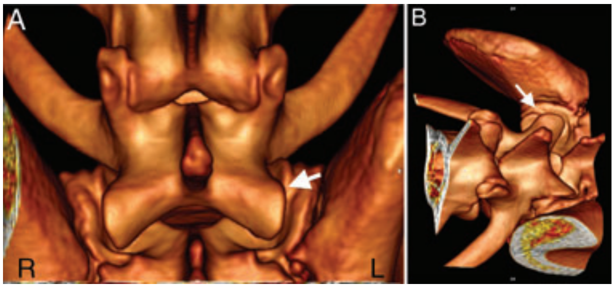

Figure 5 Three-dimensional reconstruction of a CT image demonstrating the subluxation of the LS facet joints (white arrow) before surgical treatment with transarticular facet screw stabilization. Dorsal view (A) and left dorsolateral view (B).

including nonsteroidal anti-inflammatory therapy, and complete or partial exercise restriction. The mean duration of medical treatment was 4.2 months and in most dogs, this had been initiated by the first opinion veterinarian. On clinical examination, 38.5% had pelvic limb lameness, 100% of dogs had a pain response on direct palpation of the dorsal aspect of the LS junction and 65.4% evoked a pain response on dorsal elevation of the tail, and 61.5% had pelvic limb placing deficits. LS pain was the most consistent clinical finding, which can be orthopedic, discogenic, meningeal, radicular, or a combination of causes.

For the purpose of this investigation, we have based the diagnosis of dynamic DLS on: (1) clinical signs and history consistent with DLS that were exacerbated in a neutral or extended position (jumping, running); (2) cranioventral tilting of the sacrum relative to L7 evident on lateral radiograph and CT; (3) facet joint subluxation evident of 3-dimensional CT reconstruction (Figs 5; and (4) intraoperative observation of facet joint subluxation.

CT provided additional information, including evidence of IVD degeneration of both the LS disc and cranial lumbar discs, the degree of IVD herniation and stenosis or other pathology within the intervertebral foramen and lateral recesses of L7 and the sacrum. IVD protrusion was identified in 61.5% of dogs. Based on clinical assessment, radiology, and client questionnaire, our study demonstrated an improvement in the postoperative neurologic and orthopedic status in 23 dogs surgically treated with transarticular facet screw stabilization. Statistical analysis of the data measuring the LS IVD space on lateral radiograph at the preoperative, postoperative, 6-week, and 6-month period produced significant differences at every stage, indicating that transarticular facet screw stabilization technique maintained the surgically distracted LS IVD space and 85% of owners reported their dogs were ambulating normally at 6 months after surgery, with no perceptible lames during normal activity.

Immediate postoperative or short-term complications were recorded in 5 dogs. One dog died in the perioperative period from suspected anesthesia-related pulmonary thromboembolism and cardiac arrest. Another dog was euthanatized 5 days after surgery without clinical or radiographic assessment because of perceived lack of surgical success. Another dog had a traumatic event 5 days after surgery and became acutely nonambulatory. Radiographs revealed bilateral articular facet fractures and a narrowed LS space. Surgical exploration confirmed bilateral articular facet fractures and the LS joint was stabilized using 4 bone screws and polymethylmethacrylate. Recovery in this dog was uneventful. The remaining 2 complications related to the development of pain and exercise intolerance because of screw migration at 14 and 17 weeks after surgery. In both dogs, the screws were removed and the clinical recovery in these dogs was unremarkable. Surgical complications of transarticular facet screw stabilization have been described, which include fracture of L7 articular facet, iatrogenic nerve root damage, poor implant positioning, inadequate decompression, and implant failure.[14]

In agreement with previous reports, urinary incontinence was an infrequent finding.[4,9,20] Two dogs had signs of urinary incontinence at the time of referral. One dog had resolution of clinical signs after surgery, the other dog had ongoing urinary problems, and has been treated with phenoxybenzamine and manual bladder expression for 36 months after surgery. This is consistent with other studies that have reported that dogs with urinary incontinence showed less overall improvement after decompressive surgery, most likely because of irreversible localized damage to the branches of the pelvic and pudendal nerves.[9,15,18,19]

All dogs categorized as working dogs returned to full work after surgery. Three dogs returned to full work between 6 and 12 months after surgery and 1 dog returned to full work at 14 months after surgery. Although the numbers of working dogs in this study were small, this finding was comparable with other reports.[8,11,12] In 2003, a retrospective analysis of military working dogs over a 9-year period demonstrated an overall success for dogs returning to full work was 41%, 38% improved, and 20% never returned to work.[8]

The LS joint has the highest mobility of the lumbar spine and thus is susceptible to tremendous biomechanical loading.[29] The specific role that LS instability plays in canine DLS is yet to be characterized and it is unknown if the LS junction is predisposed to mechanical instability or if dynamic instability is an inevitable consequence of DLS. It is undetermined if degeneration of the wedge-shaped LS IVD predisposes to cranioventral tilting of the sacrum and thus joint laxity. It is plausible that abnormal motion at the LS junction, whether primary or resultant, could contribute to failure of the IVD and supportive ligamentous structures, which is supported by the high prevalence of DLS in medium-to-large breed dogs of active nature.[1,14] Dorsal laminectomy as means of decompression is not sufficient to eliminate dynamic compression at the degenerative LS junction. Without stabilization, a degenerate and hypermobile LS joint will continue to cause dynamic compression at the caudal equina and be a stimulus for osseous and soft tissue hypertrophy.

Definitive diagnosis of LS instability remains problematic in the diagnostic and preoperative surgical decision-making process. The role of diagnostic imaging continues to play an increasingly significant role in the precise identification and assessment of pathology (dynamic and persistent) at the LS junction.[10,25,28] In this study CT, specifically assisted with our identification of LS IVD degeneration and of facet joint subluxation, indicating joint instability, particularly with 3-dimensional reconstruction (Fig 5). Dog positioning can influence the true LS foraminal and vertebral dimensions therefore may influence the accuracy of assessing DLS and LS instability in the preoperative stage.[19,29] LS alignment is dependent on the position of the dog during diagnostic imaging studies and while on the surgical table.[7] Studies have reported a lower number of disc protrusions in surgery than were seen on diagnostic imaging, which was concluded to be associated to variation in positioning.[19,28]

The major limitation of our study was the difficulty in getting larger numbers of owners to commit to additional sedation and radiography of their dogs for long-term radiographic assessment. Despite the retrospective nature of assessment, sufficient dogs were available to allow for statistical analysis of the radiographic findings. Using owner evaluations to assess surgical outcome is questionable as differences in owners' perceptions of lameness compared to force plate analysis have been reported for other surgical procedures. Several external factors may influence owners' opinion of postoperative recovery such as cost of the procedure, the preconceived expectation of the long-term activity level of their dog, and a positive relationship with the hospital or veterinarian. Despite these reservations, owner satisfaction can be used to estimate functional outcome after surgery.[30]

Future investigations, including prospective studies on the diagnosis and surgical outcome in dogs with dynamic DLS should focus on objective determination of dynamic instability and objective assessment of outcome for example by measuring ground reaction forces of pelvic limbs using force plate analysis. For athletic and working dogs and those with intermittent signs, it may be necessary to perform more in-depth imaging studies, including CT and MRI series of different positions and ranges of motion at the LS junction to determine if the clinical signs are associated with a dynamic compressive process.

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