Long-Term Outcome Following Lateral Foraminotomy as Treatment for Canine Degenerative Lumbosacral Stenosis

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Abstract

Lateral foraminotomy has been described as an effective surgical treatment for foraminal stenosis in the treatment of degenerative Lumbosacral Stenosis (DLSS) in dogs. Clinical records were reviewed from 45 dogs which had undergone lateral foraminotomy at the lumbosacral junction either alone or in combination with decompressive midline dorsal laminectomy. Short-term outcome at 6 weeks was assessed by the surgeon to be good (11.1%) or excellent (88.9%) in all 45 cases. Long-term outcome beyond 6 months for lumbosacral syndrome was assessed by the owner as excellent in all 34 cases for which follow up was available despite recurrence in 5 cases. Recurrence of clinical signs was not related to re-establishment of foraminal compression at the surgical site when assessed on repeat MRI imaging and was managed by either contralateral foraminotomy in 1 case or conservative management with excellent response.

This study confirms lateral foraminotomy as an effective procedure in the management of DLSS affected dogs suffering from foraminal stenosis and demonstrates that initial good short-term results are maintained long-term despite some treatable recurrences. Lateral foraminotomy is an effective procedure when used appropriately in DLSS with foraminal stenosis either alone or in combination with midline dorsal laminectomy.

Introduction

Degenerative Lumbosacral Stenosis (DLSS) is an acquired multifactorial condition involving various osseous and soft-tissue alterations, alongside suspected instability of the L7-S1 intervertebral disc. Clinical signs of neurological dysfunction are thought to arise from progressive compression or inflammation of the cauda equina and L7 nerves, secondary to stenosis of the vertebral canal and or intervertebral foramina (De Risio and others 2001, Gödde and Steffen 2007, Jeffery and others 2014). Diagnosis of DLSS can be challenging as it relies on the exclusion of orthopaedic, muscular and neuromuscular conditions; a compatible clinical history and advanced imaging investigations (Janssens and others 2000, De Risio and others 2001, Suwankong and others 2008, Meij and Bergknut 2010, Jeffery and others 2014).

Several non-surgical treatment modalities have been reported in DLSS including conservative management (Denny and others 1982, Ness 1994, De Decker and others 2014) or epidural steroid injection (Janssens and others 2009). Although improvement of clinical signs was described in these studies, more favourable response rates are reported following surgical treatment, with improvement in 67% to 97% of cases (Danielsson and Sjöström 1999, Janssens and others 2000, Jones and others 2000, De Risio and others 2001, Linn and others 2003, Gödde and Steffen 2007, Suwankong and others 2008, Hankin and others 2012, Smolders and others 2012, Golini and others 2014). Surgical techniques applied to DLSS are either based on stabilisation of the articular components to reduce dynamic pathology (Slocum and Devine 1986, Méheust 2000, Hankin and others 2012, Smolders and others 2012, Golini and others 2014), or decompression of neural structures (Danielsson and Sjöström 1999, Jones and others 2000, De Risio and others 2001, Linn and others 2003, Janssens and others 2000, Suwankong and others 2008, Rapp and others 2017). Decompression has mainly focussed on dorsal vertebral canal decompression via dorsal laminectomy with or without concurrent discectomy.

Foraminal stenosis is a frequent finding in DLSS being reported in 68-84% of cases (Mayhew and others 2002, Rapp and others 2017). Identification of foraminal stenosis on radiographs has been described as a negative prognostic factor following surgery (Linn and others 2003), however this was not confirmed in advanced imaging studies with CT or MRI (Jones and others 2000, Mayhew and others 2002). Traditionally decompression of the intervertebral foramina has been performed alongside L7-S1 dorsal laminectomy, through both dorsal and medial approaches, by means of extending the laminectomy (Danielsson and Sjöström 1999, Jones and others 2000, De Risio and others 2001, Linn and others 2003, Suwankong and others 2008). However, extension of the laminectomy results in limited access to lateralised foraminal compressions, increased risk of articular facet fractures, and increased instability of the lumbosacral joint (Moens and Runyon 2002, Gödde and Steffen 2007, Jeffery and others 2014, Rapp and others 2017). Alternative surgical approaches to the L7-S1 intervertebral foramina have been reported. Endoscopy-assisted foraminotomy was performed through a dorsal mini-laminectomy (Wood and others 2004) in clinically normal dogs and a cadaver study tested the feasibility of a transiliac approach to the foramen (Carozzo and others 2008). In 2007, Gödde and Steffen described a lateral approach to foraminotomy that could be performed bilaterally as a stand-alone procedure or in combination with a partial dorsal laminectomy of L7-S1. They reported 20 dogs, with only mild intra-operative complications and subsequent clinical improvement in 95% of cases with no recurrence of clinical signs (Gödde and Steffen 2007), however no long-term follow up studies have been reported.

This retrospective case series reviews the short and long-term outcome in a larger cohort of patients who underwent lateral foraminotomy in the treatment of lumbosacral foraminal stenosis.

Material and Methods

Animals

Medical records of dogs undergoing lateral lumbosacral foraminotomy presented to the neurology service at Dovecote Veterinary Hospital between May 2012 and January 2017 were reviewed. Cases were included when presented with clinical signs compatible with a lumbosacral neurolocalisation, when magnetic resonance imaging (MRI) evidence of foraminal stenosis was found, and unilateral or bilateral foraminotomy was performed either alone or in combination with midline dorsal laminectomy. Dogs were excluded if there was evidence of a concomitant relevant orthopaedic, neoplastic or inflammatory disease. Further to this, all cases in which a herniated disc extrusion was identified were excluded, as this is a clinically distinct pathology from DLSS.

Signalment and clinical information on presentation was recorded, including any previous treatment for DLSS. Dogs were classified as pet dogs or working dogs, a category which included agility dogs. Clinical signs consistent with a lumbosacral neurolocalisation consisted of lumbosacral pain, reluctance to climb stairs, jump or rise from sitting, lameness, and neurologic deficits (i.e. reduced flexor withdrawal, proprioceptive deficits, nerve root signature/toe touching, tail paresis, absent perineal reflex).

Dogs were further classified into pre-surgical groups according to severity of clinical and neurological signs (Table 1) using a modified scoring system (Danielsson and Sjöström 1999, Gödde and Steffen 2007). The nomenclature “lateral foraminotomy” was used throughout this study, referring to the lateral foraminotomy approach and technique described elsewhere (Gödde and Steffen 2007).

Advanced Imaging

All dogs underwent MRI under general anaesthesia using a low field 0.25 Tesla (T) permanent magnet (Esaote VetMR Grande, Genova, Italy). MRI was performed in dogs in lateral recumbency in a neutral position, using a dedicated DPA spinal coil. Imaging studies included a minimum of T2-weighted (T2W) sagittal and transverse images and dorsal short tau inversion recovery (STIR) images. MRI scans were assessed by board-certified neurologists (ML, MT). Foraminal stenosis was determined when one or more of the following findings were found: (1) complete loss of fat signal or only a minimal rim of fat signal left in the foraminal zone in parasagittal or transverse T2W images (Gödde and Steffen 2007) (Figure 1), (2) presence of a compressive asymmetric intervertebral disc protrusion on transverse T2W images at the level of the intervertebral foramina. The presence of an ipsilateral hyperintense L7 nerve root on transverse T2W images and dorsal STIR (Figure 2) supported a diagnosis of foraminal stenosis, although this was not used as a definitive criterion. Vertebral canal stenosis was defined by the presence of over 25% of lumbosacral vertebral canal attenuation on midsagittal images (Jones and others 2000, Gödde and Steffen 2007). Subsequent lumbosacral MRI studies were retrieved when available, and compared with pre-operative MRI studies. Comparison focused on assessment of subjective evidence of recurrence of foraminal stenosis and nerve root swelling. Foraminal stenosis and nerve root swelling were evaluated as described above. Pre-operative presence of nerve swelling was described. Duration of clinical signs in these cases was also reported.

Surgical procedures

Evidence of foraminal stenosis at the level of the lumbosacral junction on MRI was seen as an indication for a lateral foraminotomy (unilateral or bilateral). Vertebral canal stenosis on MRI was an indication for performing a concurrent dorsal laminectomy. Surgical procedures were performed by two different board-certified neurologists (ML, MT). Information on intra and post-operative surgical complications was retrieved. Following surgery, dogs were discharged with instructions of cage rest for 4 to 6 weeks, rehabilitation and concurrent pain-relief as required. Dogs would then be allowed to gradually resume regular exercise and routine.

Outcome and recurrence

Short-term outcome was acquired from postoperative consultations with a board-certified neurologist performed at 6 weeks and within the initial 6 months following surgery. Following this period of time, long-term outcome was obtained through telephonic interviews with the owners or, in case of relapse, subsequent consultation data was utilised.

Outcome was considered (1) excellent if complete resolution of clinical signs was present at follow-up consultations or the owner considered the dog to be clinically normal (2) good if there was substantial but incomplete improvement in clinical signs or the owner considered the dog to have some recurrent episodes of pain or lameness (3) poor if the dog did not improve after surgery or deteriorated further (De Risio and others 2001, Gödde and Steffen 2007).

Recurrence of clinical signs attributable to DLSS was determined and information on initial neurological classification, interval from surgery to recurrence and outcome post-recurrence was retrieved. Treatment post-recurrence was divided into three: repeated surgery, unrelated surgery and non-surgical. Repeated surgery included cases where re-intervention of previously operated site was performed. Unrelated surgery included cases where a new surgery of an unrelated surgical site was performed. Non-surgical included cases where new surgery was not performed. Further details on specific cases were reported when considered relevant to the scope of the study.

Results

Included animals

45 dogs were identified which had undergone lateral foraminotomy. Breed distribution was German Shepherd Dog (n=8), Border Collie (7), Crossbreed (6), Cocker Spaniel (5), Dalmatian (4), Labrador Retriever (3), Boxer (3), Rottweiler (2), German Short-Haired Pointer (2), Belgian Malinois, Gordon Setter, Golden Retriever, Lurcher and Weimaraner (1 for each). 27 males and 18 females were identified with a mean age of 74.71 months (median 76, 34 - 156). Mean duration of clinical signs before surgery was of 6.88 months (median 6; 0.75 - 30). The severity group allocation of cases before surgery was: mild (n=26), moderate (n=16) or severe (n=3) (Table 1). Eleven (24.4%) were working or agility dogs.

Pre-operative treatments

Three dogs had previously undergone dorsal laminectomy with concurrent unilateral extension at 16, 17 and 60 months prior to lateral foraminotomy. Long term response to surgery was considered inadequate and lateral foraminotomy was performed ipsilaterally in all 3 cases. One further dog had received an epidural steroid injection with a transient 2 weeks' improvement in clinical signs, whilst the remaining 41 dogs (91.1%) had previously shown inadequate response to systemic conservative therapy with rest and analgesia.

Surgical procedures and complications

Unilateral lateral foraminotomy was performed in 11 dogs (24.4%), alone in 7 dogs and in combination with dorsal laminectomy in 4 dogs. Bilateral lateral foraminotomy was performed in 34 dogs (75.6%), alone in 8 dogs and with concurrent dorsal laminectomy in 26 dogs. None of the dogs underwent concurrent lumbosacral discectomy. Mild haemorrhage from abnormal vascular supply to the articular facet joint was reported as an intraoperative complication in 1 case.. Postoperative complications were present in 12 dogs and included subcutaneous seroma in 7 dogs (15.6%), suspected wound infection responsive to broad-spectrum antibiotic course in 2 dogs and increased pain within the first 4 weeks in 3 dogs. Suspected wound infection was not confirmed with culture and sensitivity tests. All of these complications were resolved within 4 weeks following surgery.

Short-term outcome

Short-term outcome information was available for all patients and was considered good in 5 cases (11.1%) and excellent in the remaining 40 cases (88.9%).

Long-term outcome

Long-term outcome was available in 34 cases (75.5%) with a mean follow-up time of 22.9 months (median 18; 8-54). Poor long-term neurological outcome was reported in one 10-year-old male German Shepherd Dog which having initially responded well to lateral foraminotomy, subsequently developed progressive ataxia and paraparesis. Based on the clinical presentation, age, breed and normal spinal MRI findings a presumptive diagnosis of degenerative myelopathy (DM) was suspected. All 33 remaining cases were reported by the owner to have an excellent long-term outcome.

Recurrence of clinical signs was identified in 5 dogs (11.1%) and occurred in a mean of 10 months after surgery (median 8; 4-22). Initial neurological classification of these cases was mild (n=2), moderate (2) and severe (1), and all had a repeat MRI scan performed at a mean of 11.8 months following foraminotomy (median 9, 8-22). One of these dogs was the German Shepherd suspected to have developed DM. Re-establishment of foraminal compression at the surgical site was not demonstrated in any of the remaining 4 dogs (Figure 3). Nerve root swelling which had been identified on pre-surgical MRI, was also present in subsequent imaging of 4 cases (Figure 3). When nerve root swelling was not present on pre-surgical MRI this was also not identified on subsequent imaging (1 case).

Treatment following recurrence was non-surgical in four cases and one case that on cross-sectional imaging had developed a contralateral foraminal stenosis underwent lateral foraminotomy of the newly affected site. Non-surgical treatment was conservative (3) or epidural steroid-injection (1). All five cases improved following treatment and their long-term outcome was considered excellent at a mean of 26.3 months' post-recurrence (median 27; 8-43).

Discussion

The short-term clinical outcome in this cohort of patients was consistent with the findings of Gödde and Steffen in 2007 and is maintained long-term despite some episodes of recurrence. In previous studies reporting dorsal laminectomy decompression, a lack of improvement or worsening of clinical signs is reported to occur in about 15-30% of cases (Danielsson and Sjöström 1999, Janssens and others 2000, Jones and others 2000, De Risio and others 2001, Linn and others 2003, Suwankong and others 2008, Rapp and others 2017) with reports of failed surgery requiring re-intervention (Danielsson and Sjöström 1999, De Risio and others 2001, Moens and Runyon 2002). The improved results from lateral foraminotomy in this study and studies reporting presence of foraminal stenosis in 68-84% of DLSS cases (Mayhew and others 2002, Rapp and others 2017) would suggest that foraminal stenosis with subsequent L7 nerve root pathology represents a significant pathology in DLSS that requires consideration when selecting surgical therapeutic options. Since lateral foraminotomy can address stenosis in the middle and/or exit foraminal zones as well as extra-foraminal stenosis (Gödde and Steffen 2007, Carozzo and others 2008) it would appear that this more lateral pathology is significant in a proportion of cases. Unrecognised or untreated foraminal stenosis is an important cause of “failed back surgery syndrome”, well reported in human medicine (Fritsch and others 1996, Maher and Henderson 1999).

It has been postulated that failure in the majority of cases following decompression is related with an increased risk of articular facet fractures, instability and inappropriate foraminal stenosis decompression (Moens and Runyon 2002, Gödde and Steffen 2007, Jeffery and others 2014, Rapp and others 2017). Lateral foraminotomy has been increasingly performed since it was first described a decade ago (Gödde and Steffen 2007) and allows for effective decompression of the neuroforamen. Besides the clearer and more direct access it provides, this surgery also offers the advantage that it can be used in combination with dorsal laminectomy without increasing instability. It is worth comparison with alternative techniques involving stabilisation that by reducing mobility and creating distraction at the L7-S1 articulation may work by a similar mechanism to effectively enlarge the foramina and reduce ongoing concussive insult to the L7 nerve within the foramina (Slocum and Devine 1986, Méheust 2000, Hankin and others 2012, Smolders and others 2012, Golini and others 2014). Stabilisation procedures carry post-operative risks of complication due to implant failure (Hankin and others 2012, Smolders and others 2012, Golini and others 2014).

Similar to previous reports the German Shepherd was the most affected breed in this study (Ness 1994, Danielsson and Sjöström 1999, De Risio and others 2001, Gödde and Steffen 2007, Suwankong and others 2008). Interestingly Cocker Spaniels, a breed reported to present with caudal lumbar disc herniation (Cardy and others 2016), represented 8.8% of this population while being sparsely represented in previous DLSS reports (Slocum and Devine 1986, Danielsson and Sjöström 1999, Janssens and others 2000, Méheust 2000, De Risio and others 2001, Linn and others 2003, Suwankong and others 2008, Hankin and others 2012, Smolders and others 2012, Golini and others 2014, Rapp and others 2017).

The majority of cases in this study underwent surgery following unsuccessful conservative treatment (91.1%). Interestingly three cases had previously undergone dorsal laminectomy. In these three cases foraminal stenosis had been identified at the time of diagnosis and the dorsal laminectomy had been extended unilaterally, in an attempt to relieve the foramina. Dorsal laminectomy of these cases was performed at a time prior to lateral foraminotomy being offered in this institution. A further case presented with a transient response to epidural-steroid injection with recurrence. Since all of these cases had an excellent outcome following foraminotomy alone this supports the hypothesis that the clinical signs were due to neuroforaminal entrapment rather than vertebral canal stenosis.

In this population, both short- and long-term improvement of clinical signs were identified, with a long-term complete resolution of clinical signs in 97.1% of cases. This percentage is the highest reported in surgical management of DLSS (Danielsson and Sjöström 1999, Janssens and others 2000, Jones and others 2000, De Risio and others 2001, Linn and others 2003, Gödde and Steffen 2007, Suwankong and others 2008, Hankin and others 2012, Smolders and others 2012, Golini and others 2014) which is in accordance to previously reported excellent results of this technique (Gödde and Steffen 2007). Being a retrospective study, long-term follow-up was based mainly on telephonic interviews with owners, which can have biased the results. However, the fact that a single case presented a poor outcome which was deemed unrelated to DLSS, reinforce the significance of these results, at least in comparison with previously reported stand-alone dorsal laminectomy outcomes.

Recurrence of clinical signs following surgical therapy for DLSS has been reported for dorsal decompression via a dorsal laminectomy requiring further surgical intervention (Danielsson and Sjöström 1999, De Risio and others 2001, Moens and Runyon 2002), but has not been previously reported following lateral foraminotomy (Gödde and Steffen 2007). Recurrence in the current study was not shown to be related to reestablishment of foraminal stenosis of the previously operated site on MRI and most cases were managed successfully with non-surgical measures. In the case where a second surgery was required this was at the contralateral foramen which had not been previously surgically decompressed. Evidence of contralateral foraminal stenosis was not present on the initial MRI study and previous reports suggest that MRI findings do not always correlate to intra-operative findings (Suwankong and others 2006). A contralateral foraminotomy resolved the clinical signs suggesting this was the result of progression of DLSS rather than surgical failure or failure to identify foraminal stenosis on initial MRI.

New bone formation following foraminotomy has been reported previously (Wood and others 2004) and this in conjunction with fibrous tissue generation could lead to a renewed foraminal stenosis with compression of the nerve root (Gödde and Steffen 2007). Subsequent advanced imaging in five dogs, performed at least 8 months following surgery, revealed that the foraminal enlargement that had been achieved by foraminotomy was maintained and that there was no evident spondylosis producing progressive stenosis. However, a larger cohort study with post-operative imaging would be required to confirm this.

The persistence of nerve enlargement identified in 4/5 dogs supports experimental studies documenting chronic irreversible nerve root swelling following entrapment in dogs (Yoshizawa and others 1995). Compression of the nerve root results in impaired venous and lymphatic drainage resulting in endoneurial oedema (Yoshizawa and others 1995). Interstitial and perivascular fibrosis then ensues contributing to irreversible nerve root enlargement (Lindahl and Rexed 1951). Despite persistent hypertrophy of the nerve root on MRI, the long-term outcome in all cases post-operatively was considered excellent.

A number of limitations exist in the current study. Data was collected retrospectively and therefore the population and procedures were not-standardised. However, a set of standardised procedures was adhered to in terms of medical note taking, advanced imaging, surgical management, hospitalisation and subsequent treatment making the data less prone to recall bias. Further to this, short-term follow-up information relied on the expertise of the same people that performed surgery potentiating clinician bias and long-term follow-up was based upon telephone interviews which are both subjective and prone to a caregiver placebo effect. The follow-up period is also variable and a much longer-term follow-up in all cases may have altered our outcome.

The MRI studies used for diagnosis were low-field and some authors may suggest that greater information could be achieved using high-field MRI. However, in human degenerative lumbar disease excellent agreement was found between high and low-field magnets, when comparing vertebral canal stenosis, lateral recess and exit foraminal stenosis as well as good agreement when assessing for spinal nerve compression (Lee and others 2015).

This is the largest reported population of dogs undergoing lateral foraminotomy following a previously reported procedure (Gödde and Steffen 2007). The results of this study further confirm that lateral foraminotomy is a safe and reliable technique that can be used to address DLSS affected dogs suffering from foraminal stenosis, leading to minimal intra-operative and post-operative complications when used either alone or in combination with dorsal laminectomy. Long-term clinical improvement was achieved in all cases despite some transient recurrences which responded to conservative therapy. It is our belief that neuroforaminal entrapment may be a common cause for failure of dorsal laminectomy in the subset of patients in which this has been reported. This study demonstrates the importance of achieving an accurate diagnosis for the site of ongoing pathology in DLSS and that the lateral foraminotomy has a place in the repertoire of surgical approaches to DLSS which requires consideration when evidence of foraminal stenosis is present.

Disclosure statement

Authors disclose no conflict of interest.

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Tables

Table 1. Classification of Dogs According to Severity of Clinical and Neurological Signs

Group 1 (mild)
Lumbosacral pain
Reluctance to climb stairs, jump or raise up
Lameness
Muscle atrophy
No neurologic deficits
Group 2 (moderate)
Lumbosacral pain
Reluctance to climb stairs, jump or raise up
Lameness
Muscle atrophy
Moderate neurologic deficits (e.g. reduced flexor withdrawal, proprioceptive deficits, nerve root signature/toe touching)
Group 3 (severe)
Lumbosacral pain
Reluctance to climb stairs, jump or raise up
Lameness
Muscle atrophy
Severe neurologic deficits (e.g. tail paresis, absent perineal reflex)

Legends

Figure 1. T2W parasagittal images of a dog with right unilateral foraminal stenosis. White arrows indicate the intervertebral foramina. An almost complete fat signal loss is noticeable in the affected foramen (A). Foraminal stenosis can be observed more clearly when affected (A) and non-affected (B) foramina are compared.

Figure 2. T2W transverse (A) and dorsal STIR (B) images of a dog with right unilateral foraminal stenosis. Subjective nerve swelling on the affected site can be observed on both images, indicated by white arrows. Hyperintensity obtained on dorsal STIR (B) is notable when compared to contralateral unaffected foramen.

Figure 3. Pre-operative dorsal STIR (A1), T2W transverse (B1), T2W parasagittal (C1) and 22 months postoperative dorsal STIR (A2), T2W transverse (B2), T2W parasagittal (C2) of a dog with right unilateral foraminal stenosis. Right nerve root swelling is noticeably decreased 22 months following surgery (white arrows); however, it is still subjectively enlarged when compared with the contralateral nerve root. Right foraminal stenosis (white arrow) is clearly noticeable previously to surgery (B1) being resolved following surgery (B2). Lateral foraminotomy post-surgical borders are clearly identified (C2) with no evidence of reestablishment of stenosis. This patient underwent a right-sided lateral foraminotomy, with recurrence of clinical signs 22 months following surgery. Right foraminal stenosis was not proven to be re-established and following conservative management, complete resolution of clinical signs was achieved.