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Observational Report

Prognosis for Recovery of Foot Drop after Transforaminal Endoscopic Decompression of Far Lateral Lumbar 5-Sacral 1 Herniated Disc: Case Series

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Background: Foot drop that results from compression of the exiting L5 nerve as a result of far lateral disc herniation (FLDH) at L5-S1 poses a significant surgical challenge to the minimally-invasive spine surgeon given the narrow corridor for an extraforaminal approach because of the high iliac crest.

Objectives: Here we describe our experience with transforaminal endoscopic decompression for the treatment of foot drop secondary to FLDH at L5-S1.

Study Design: Retrospective case review.

Setting: This study took place in a single-center, academic hospital.

Methods: A technique for the transforaminal endoscopic treatment of foot drop secondary to L5-S1 FLDH is presented in a series of 5 consecutive patients treated over a period of 3 years. Preoperative and postoperative clinical data with 1-year follow-up are presented.

Results: A consecutive series of 211 patients who underwent transforaminal endoscopic treatment for lumbar radiculopathy between 2011 and 2014 are presented. Seventy-seven patients had L5-S1 discectomies and 5 of those patients presented with foot drop and FLDH. The mean visual analog scale score for radicular pain improved from an average pain score before surgery of 7.2 to 0.8 one year after surgery, and the mean motor score for anterior tibialis strength improved from an average motor score before surgery of 2.6 to 4.8 one year after surgery.

Limitations: Small case series evaluated retrospectively with one year follow-up.

Conclusions: Transforaminal endoscopic surgical access to FLDH pathology may be a unique approach to the treatment of foot drop because it allows for neural decompression of disc and foraminal pathology without requiring significant destabilizing bone removal.

Key words: Endoscopic spine surgery, minimally-invasive, transforaminal, foot drop, far lateral disc herniation

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The surgical treatment of far lateral lumbar 5-sacra1 disc herniations can be challenging because accessing the herniation extraforaminally is only possible through a small window made narrower because of the unique anatomic barrier created by the iliac crest and ala, and accessing the herniation medially requires almost complete obliteration of the unilateral facet and possible need for fusion.

Transforaminal endoscopic lumbar discectomy is a minimally-invasive spinal surgery procedure that was introduced by Kambin and Gellman (1) in 1983.

Advances in endoscopic visualization and surgical instrumentation have led to an increased popularity of the technique; however, endoscopic spine surgery presents challenges to surgeons considering adopting the technique in terms of novel targeting and visualization. Here, we describe our experience with the clinical recovery of anterior tibialis (AT) strength and improvement in pain for patients treated with transforaminal endoscopic discectomy for far lateral L5-S1 herniated discs presenting with foot drop.

Methods

Preoperative Clinical Data

Two hundred eleven patients were treated with endoscopic spine surgery for lumbar disc herniation (LDH) between 2011 and 2014 at our institution. There were 77 patients with L5-S1 herniated discs and of these, 5 presented with far lateral herniations and foot drop. Figures 1-3 illustrate the magnetic resonance imaging (MRI) features of several of these cases. In each case, the lumbar MRI revealed compression of the exiting L5 nerve. Patients presented between 3 weeks and 5 months after the onset of their foot drop. Table 1 provides the preoperative clinical features of each patient and their postoperative results. One patient presented with FLDH 13 years after an artificial disc placement at L5-S1.

Transforaminal Endoscopic Operative Technique

The procedures were performed under local analgesia and intravenous sedation; the level of anesthetic was titrated so the patient was able to communicate with the surgeon throughout the procedure. The patients were positioned prone on the Jackson table and Wilson frame. The Joimax TESSYS (Joimax, Germany) endoscopic system was used for each procedure. Percutaneous entry was established entering through the skin 12-14 cm lateral to the midline. Using intermittent fluoroscopic guidance, alternating between lateral and anterior-posterior (AP) view, a 15-cm 18-gauge needle was advanced and the tip placed on the superior endplate of the S1 vertebral body first by touching the superior articulating process (SAP) and being deflected ventrally. "Hugging" the SAP allowed for maximal removal of ventral SAP bone to open the foramen for visualization. Sequential reamers were used to remove the ventral aspect of the superior facet. A 7-mm beveled tubular retractor was then placed in Kambin's triangle (the triangle defined by the exiting and traversing nerve roots and the superior endplate of the inferior vertebra) (Figs. 1-3). The working channel endoscope was then placed in the tubular retractor and the L5 nerve and herniated disc were visualized (Fig. 3). Endoscopic grasping forceps were used to remove the herniated disc material (Fig. 3). As disc material was removed, the L5 nerve changed in appearance from a

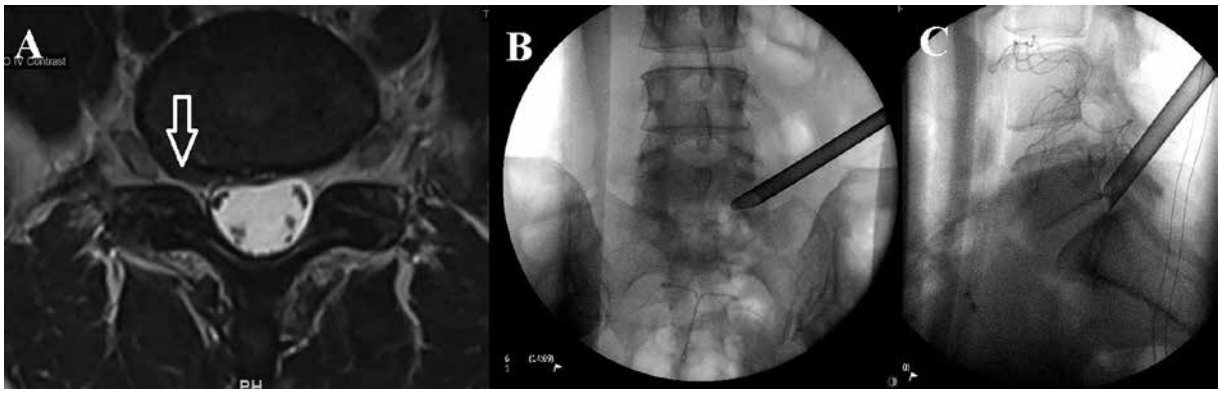

Fig. 1. *Preoperative lumbar MRI and intraoperative fluoroscopy. (A) T2 axial MRI shows the disc herniation in the right L5-S1 foramen compressing the L5 nerve. (B) AP intraoperative fluoroscopic image displaying the beveled tubular retractor in the foramen. (C) Lateral intraoperative fluoroscopic image showing the tubular retractor in the L5-S1 foramen (positioned on the disc, not in the disc).*

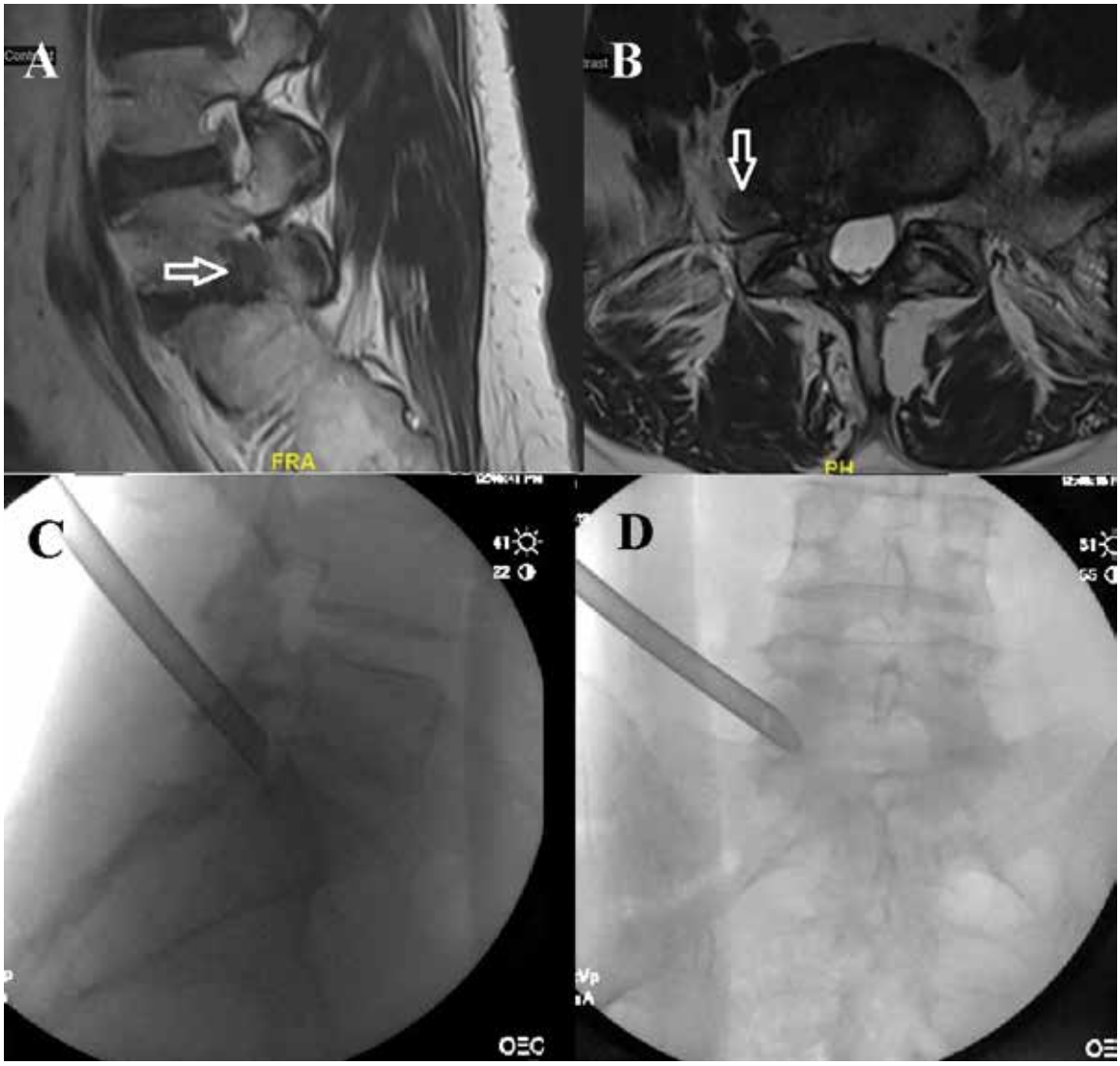

Fig. 2. *Preoperative lumbar MRI and intraoperative fluoroscopy. (A) T2 sagittal MRI shows the disc herniation in the right L5-S1 foramen compressing the L5 nerve. (B) T2 axial MRI shows the disc herniation in the right L5-S1 foramen compressing the L5 nerve. (C) Lateral intraoperative fluoroscopic image showing the tubular retractor in the L5-S1 foramen (positioned on the disc, not in the disc). (D) AP intraoperative fluoroscopic image displaying the beveled tubular retractor in the foramen.*

firm, white, tense appearance to a relaxed, pink, well-decompressed appearance. The patients were able to communicate during their surgery when their radicular pain had completely resolved. After the working channel and endoscope were removed, pressure was held on the 5-mm incision for 5 minutes, and the wound was closed with a single interrupted suture.

Results

The surgery was performed under MAC (monitored anesthesia care) anesthesia, so the patients were examined in the operating room immediately and were found to have improved strength and reduced radicular pain at rest or with straight leg raise. The patients were seen at 2 weeks, 6 weeks, 3 months, and one year. The

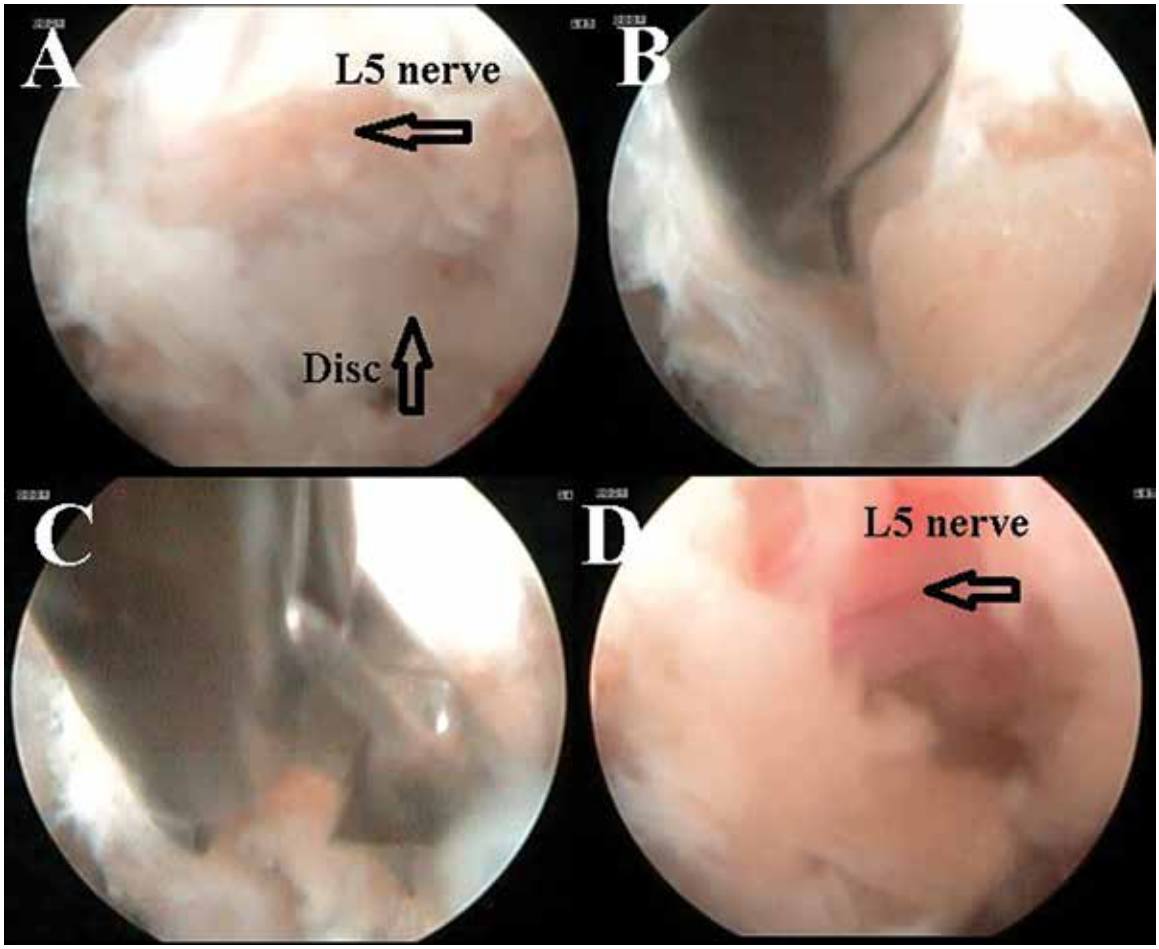

Fig. 3. *Endoscopic camera views of surgical procedure for the right L5-S1 endoscopic discectomy. (A) Endoscopic camera-view shows the herniated disc fragment in the foramen compressing the very white L5 nerve. The endoscope uses a 30° angled camera and the endoscope is held upside down looking out at the L5 nerve. (B) Endoscopic camera view shows the grasper reaching in and medial to the L5 nerve to remove the disc fragment. (C) Endoscopic camera view shows the grasper open horizontal to the L5 nerve. (D) Endoscopic camera view shows pink, well-decompressed nerve after removing the herniated disc fragment.*

average patient had a preoperative visual analog scale (VAS) pain score for radicular pain of 7.2. The pain score improved on average by 81% at 3 months and by 89% at one year (Table 1). Medical Research Council motor scale was used to measure motor strength. The average AT muscle motor strength was 2.6 preoperatively and improved by 77% at 3 months and by 85% at one year (Table 1). There were no postoperative complications such as infection, spinal fluid leak, instability, or nerve dysesthesia.

Discussion

Weakness of the tibialis anterior muscle can lead to foot drop (dorsiflexion weakness) and cause major disability. Compression of the L5 nerve root is the most common etiology, although less commonly the L4 or S1 nerves have been implicated in dorsiflexion weakness. Studies evaluating the recovery of foot drop following conventional surgery for lumbar degenerative disease have generally shown that most patients show some improvement, but usually do not regain normal

Table 1. *Preoperative and postoperative clinical data.*

Age (yrs)	Gender	Side	Duration of Foot Drop	Preoperative VAS; AT Strength	3 mo Postoperative VAS; AT Strength	12 mo Postoperative VAS; AT Strength
48	F	R	6 wks	VAS = 6; AT = 3/5	VAS = 0; AT = 5/5	VAS = 0; AT = 5/5
58	F	R	3 wks	VAS = 10; AT = 1/5	VAS = 1; AT = 4/5	VAS = 0; AT = 4/5
68	M	R	4 wks	VAS = 5; AT = 3/5	VAS = 0; AT = 5/5	VAS = 0; AT = 5/5
73	F	L	4 wks	VAS = 7; AT = 3/5	VAS = 2; AT = 5/5	VAS = 1; AT = 5/5
81	F	L	5 mos	VAS = 8; AT = 3/5	VAS = 4; AT = 4/5	VAS = 3; AT = 5/5

strength based on manual muscle testing (MMT). In a series of 135 patients reported by Liu et al (2), 113 (83%) patients showed improvement in strength but only 21 (15%) patients improved to an MMT of > 4. Making definitive conclusions based on the current literature is difficult as most studies have been retrospective, have a small sample size, and include a variety of offending causes and surgical procedures. Furthermore, the definition of foot drop remains controversial in the literature as some studies define this as MMT < 5 and others MMT < 3.

Several reports have demonstrated that the duration of dorsiflexion weakness, severity of weakness, and early surgical intervention are the major predictors of subsequent improvement (3-8). Macki et al (3) evaluated 71 patients at a single institution undergoing surgery for foot drop caused by lumbar degenerative disease. Most patients had LDH and the foot drop improved in 52 (73%) patients. They noted a significant association between preoperative muscle strength and foot drop improvement. Using a discrete time proportional hazards model, they demonstrated that every increase in one grade of preoperative MMT resulted in a 10% chance of foot drop improvement. In addition, they evaluated discrete time points for the timing of surgery (one day, one week, 6 weeks, 6 months, one year, and > one year) and found that patients were less likely to improve with increasing time to surgery. Each increase in one of these delayed time periods to surgery resulted in a decrease in probability of foot drop improvement by 33%. Aono et al (4) evaluated 46 patients with foot drop caused by lumbar compression and found 61% showed some degree of improvement in muscle strength. They also found that palsy duration and preoperative strength were significant factors associated with improvement (4). There is no established consensus on the viability of these prognostic factors, as Girardi et al (9) performed a retrospective analysis of 55 patients with lumbar degenerative disease and foot drop and found that although the foot drop did improve significantly, there was no significant relationship found between extent of recovery and duration or severity of preoperative weakness.

Foot Drop in Far Lateral L5-S1 Disc Herniation

Although L4-5 disc herniation is the most common lumbar pathology to cause foot drop, L5-S1 disc herniation can be identified as the cause in up to 25% of cases (10). Often, disc herniations at this level are in a far lateral position that can affect the exiting L5 nerve root, with or without compression of the traversing S1 nerve root. Far lateral disc herniation (FLDH) at L5-S1 represent only 2% to 4% of symptomatic LDH (11-13), but are associated with more frequent neurologic deficits when compared to posterolateral herniations (13,14). FLDH are also typically associated with more severe radicular leg pain that is thought to be related to compression of the dorsal root ganglion. Although nonsurgical methods may be able control pain, surgery is frequently necessary for treatment of neurologic deficits, such as foot drop (15). Ma et al (16) found in a retrospective analysis that 22.9% of patients who underwent surgery for LDH suffered from foot drop, and identified far lateral location of herniation as a significant predictor of foot drop, along with diabetes mellitus, acute or acute-on-chronic presentation, disc calcification, canal occupancy rate > 50%, and anteroposterior diameter of the canal. However, the specific prognosis of foot drop from far lateral L5-S1

herniated discs has not been fully evaluated in the literature.

Endoscopic Surgery for FLDH

The use of endoscopic procedures for the treatment of FLDH provides several advantages over traditional open surgical techniques. These include reduced postoperative pain, shorter hospital stays, quicker return to work (17-19), reduced risk of morbidity, and recurrence of back pain (20). Minimally-invasive techniques at the L5-S1 level are anatomically difficult because of the high iliac crest, sacral ala, and large L5 transverse process preventing entry (21), although a number of new technical refinements have made endoscopic procedures an attractive approach to FLDH at L5-S1 (22-27). Furthermore, endoscopic techniques do not require significant retraction of the compromised nerve that can potentially cause ischemia and further nerve injury. Furthermore, in a recent randomized study comparing percutaneous transforaminal endoscopic discectomy to traditional microdiscectomy, Chen et al (28) reported that the endoscopic technique was superior for disc herniation in a far lateral position.

Recovery of foot drop specifically related to FLDH has been described infrequently, especially after endoscopic surgery. Chun and Park (20) in 2016 first demonstrated the use of endoscopic techniques for a patient with L5-S1 FLDH and associated foot drop by using a modified percutaneous endoscopic lumbar discectomy technique. The patient had significant improvement of pain and full resolution of foot drop after the procedure, although the authors cite that root compression causing foot drop could be worsened by device landing and irrigating pressure from endoscopic techniques (20). Wang et al (10) subsequently performed an analysis of 32 patients receiving transforaminal endoscopic discectomy for LDH causing foot drop, 8 of which had L5-S1 disc herniation. Overall, most of their patients recovered to 4/5 or greater strength, however, they did not report specific results for the subgroup of patients with L5-S1 disc herniation or specify if they were in a far lateral position (10).

Conclusion

Although endoscopic procedures remain an excellent surgical option for L5-S1 FLDH, further evaluation of the prognosis of foot drop in this select group of patients is warranted.

The authors present here for consideration a small consecutive series of patients with L5-S1 FLDH presenting with foot drop who were treated successfully with transforaminal endoscopic surgery.

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