Retrospective Review

Awake, Transforaminal Endoscopic Lumbar Decompression Surgery to Treat L5-S1 Adjacent Segment Disease: A Case Series

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Background: Lumbar radiculopathy secondary to L5-S1 degenerative changes adjacent to a lumbar fusion usually requires extending the fusion to include the degenerative L5-S1 level; this revision surgery can often be a very invasive procedure.

Objective: To describe outcomes of awake, transforaminal endoscopic decompression surgery for patients presenting with lumbar radiculopathy as a result of L5-S1 degenerative disc disease below lumbar fusions.

Study Design: Retrospective chart review.

Methods: Awake, endoscopic decompression surgery was performed in 538 patients over a 5-year period from 2014 through 2019 by a single surgeon at a single institution. The records of 18 consecutive patients who underwent transforaminal lumbar endoscopic decompression surgery to treat radiculopathy secondary to L5-S1 adjacent segment disease were retrospectively reviewed. All included patients were followed for at least 2 years after surgery. All patients were treated at L5-S1 and had fusion constructs that ended at L5.

Results: Thirteen men and 5 women patients ranging in age from 38 to 83 (average age of 68.9 ± 11.5) were treated for symptomatic adjacent segment disease at L5-S1 during the 5-year time period. Surgery was successful in all cases, except 2 patients (11%) at 2 years follow-up had recurrent symptomatic pathology at L5-S1 and required additional surgical treatment. The average preoperative visual analog scale (VAS) and Oswestry Disability Index (ODI) scores were 7.5(± 1.3) and 45.3 (± 12.3) respectively. The average 2-year postoperative VAS and ODI scores were 2.4 (± 1.5) and 22.5 (± 9.6) respectively, excluding the 2 patients with recurrent pathology. The average body mass index (BMI) and L5-S1 disc height in the 2-year successful group (n = 16) were 30.6 (± 7.4) and 8.7 mm (± 3.5 mm) respectively; the average BMI and L5-S1 disc height in the 2-year failure group (n = 2) were 25.8 (± 5.9) and 7.9 (± 2.6) respectively.

Limitations: This was a retrospective case series.

Conclusions: Endoscopic spine surgery offers patients with fusions that terminate at L5 a safe and effective option for treatment of lumbar degenerative spine disease at L5-S1 below their fusion constructs. A longer follow-up and a larger prospective study would be necessary to consider the utility of endoscopic compression versus extending the fusion construct.

Key words: Endoscopic discectomy, transforaminal, TESSYS, radiculopathy, adjacent segment disease

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Adjacent segment disease (ASD), defined as the long-term development of symptomatic degenerative changes at a segmental level either immediately rostral or caudal to a spinal fusion construct, is estimated to occur within 10 years of surgery in nearly 20% of patients who undergo lumbar spine fusion (1). The development of ASD is likely multifactorial; however, it is likely that the alterations in biomechanical load bearing and motion across segments adjacent to a fusion construct result in an increased rate of degeneration at those levels (2,3). ASD typically manifests cephalad to fusion constructs; however, advanced degeneration of caudal to fusion constructs, and in particular at the L5-S1 segment, have been described in lumbar fusions ending at L5 (4).

Given the role of pathologic motion and altered biomechanics on the development of ASD, posterior revision decompression surgery and extension of fusion has traditionally been the mainstay of surgical treatment for patients who fail conservative management (2,3). Minimally invasive approaches, however, offer the potential benefit of symptom alleviation without incurring the risks and complications of open posterior revision surgery or its associated postoperative recovery and possible discharge to a nursing home or rehabilitation (5). Within this context, there may be a role for endoscopic decompression surgery, without fusion, as a minimally invasive and fusion-sparing alternative in the management of select patients with symptomatic lumbar ASD at L5-S1.

Methods

Study Patients & Surgical Management

The protocol for this study was reviewed by the Institutional Review Board of Rhode Island Hospital (Providence, RI). The records of 18 consecutive patients who underwent endoscopic lumbar spine surgery for a chief concern of lumbar radiculopathy from 2014 through 2019 were reviewed. Patients included in the study had radiculopathy secondary to L5-S1 disc pathology and instrumented lumbar fusions that terminated their fusion constructs at L5. All procedures were conducted with the patients prone with local anesthesia and sedation by a single surgeon (AT) using the Joimax TESSYS endoscopic system. All patients were asked to complete the visual analog scale (VAS) for leg pain and the Oswestry Disability Index (ODI) routinely as part of their standard pre- and postoperative evaluation.

Outcome & Statistical Analysis

Primary clinical outcomes measures (VAS and ODI) were recorded preoperatively and at final follow-up 2 years postoperatively. Statistical tests employed in the outcome analysis of this study included Student's t test to measure any statistically significant association between variables using IBM SPSS Statistics software, Version 27.0. The mean, range, and standard deviation, and percentages of all nominal variables were calculated. Disc heights at L5-S1 were calculated by measuring the disc height at the mid-disc point on the midline sagittal T2-weighted magnetic resonance image.

Positioning, Anesthesia & Surgical Technique

For the endoscopic lumbar procedure, the patient was positioned prone with flexed hips and knees on a Wilson frame. The procedure was done under local anesthesia (1% lidocaine with epinephrine) and intravenous sedation. The level of anesthetic was titrated so the patient was able to communicate with the surgeon throughout the procedure. Percutaneous entry was established through the skin between 11 cm and 13 cm lateral to the midline. Using intermittent fluoroscopic guidance, alternating between a lateral and an anteroposterior view, a 15-cm, 18G needle was advanced and placed at the superior end plate of the inferior vertebral body through the Kambin triangle, between the exiting and traversing nerves. An anteroposterior fluoroscopic view was used to confirm the needle was at the medial border of the pedicle of the inferior vertebral body.

A 6-mm incision was made over the needle, a K-wire was placed in the needle, the needle was removed, and sequential dilators were placed over the K-wire. Sequential reamers were used to enlarge the neural foramen by removing the ventral aspect of the superior articulating process of the inferior vertebral body. At this point a beveled cannula tubular dilator was placed over the sequential dilators, the dilators were removed, and the 7-mm outer diameter Joimax rigid working channel endoscope channel was inserted through the tubular retractor. Under endoscopic visualization, endoscopic graspers were used to remove disc material in discectomy cases and endoscopic drills and Kerrison rongeurs, manual side-shaver drills, and high-speed endoscopic drills were used to remove bone and ligament in cases that required additional foraminotomy.

Table 1. *Patient Data*

Age	Gender	Levels Fused	Side	Preop VAS	Preop ODI	2-year postop VAS	2-year postop ODI	Failed in 2 years?	Disc Height (mm)	BMI
38	M	L2-5	L	7	48	1	26		11.9	30.3
51	M	L4-5	R	6	44	2	22		13.2	37.8
59	W	L4-5	R	7	48	1	26		7.8	42.8
61	M	L4-5	R	8	10	2	4		2.8	41.2
62	M	L4-5	R	9	54			Failed in 1 month	9.7	30
63	M	L2-5	L	7	40	1	12		12.8	33.6
67	M	L3-5	R	8	54	2	12		4.7	29.8
71	M	L4-5	R	8	46	2	20		14.0	28.2
72	W	T11-L5	R	6	36	2	28		8.6	24.1
74	M	L4-5	L	6	38	2	22		9.6	24.3
74	M	T11-L5	R	5	42	3	28		10.1	24.2
75	M	L4-5	R	9	60	4	24		5.6	25.8
76	M	L2-5	L	8	42	3	24		4.5	23.7
76	W	L1-5	L	10	68	7	46		8.4	44.4
78	W	L4-5	R	7	38	3	12		4.6	23
79	W	L4-5	R	8	54	2	24		10.3	24.2
81	M	L3-5	R	7	54	2	30		10.4	31.9
83	M	L4-5	R	9	40			Failed in 3 months	6.0	21.6
38	M	L2-5	L	7	48	1	26		11.9	30.3
51	M	L4-5	R	6	44	2	22		13.2	37.8

M = man; W = woman; L = left; R = right; BMI = body mass index

Results

Patient data are summarized in Table 1. There were no incidental durotomies, infections, or cases of neurologic injury encountered in 18 patients. Thirteen men and 5 women patients ranging in age from 38 to 83 (average age of 68.9 ± 11.5) were treated with symptomatic adjacent segment disease at L5-S1 during the 5-year time period. Surgery was successful in all cases, although 2 patients (11%) developed recurrent symptoms by 2-year follow-up and required additional surgical treatment.

The average preoperative VAS and ODI were 7.5 (± 1.3) and 45.3 (± 12.3) respectively and the average 2-year postoperative VAS and ODI were 2.4 (± 1.5) and 22.5 (± 9.6) respectively, excluding the 2 patients with recurrent pathology. The average body mass index (BMI) and L5-S1 disc height in the 2-year successful group (n = 16) were 30.6 (± 7.4) and 8.7mm (± 3.5mm) respectively; the average BMI and L5-S1 disc height in the 2-year failure group (n = 2) were 25.8 (± 5.9) and 7.9 (± 2.6) respectively. The patient age, L5-S1 disc height, and BMI of the 2 groups (2-year success versus failure) were not statistically different.

Failures

Two patients required repeat surgery in the 2-year postoperative period (Table 1). The 2 patients had L5-S1 disc herniations below L4-5 fusions: one had a transforaminal lumbar interbody fusion (Case 5) and the other had a lateral lumbar interbody fusion. Both patients had immediate improvement after surgery but developed recurrent disc herniations within 3 months of their endoscopic procedures.

Case Examples

Case 1: A 72-year-old woman with a prior history a T11 to L5 fusion presented with 2 years of a right L5-S1 radiculopathy despite conservative treatment. A magnetic resonance image (MRI) demonstrated the previous fusion and the right L5-S1 foraminal disc herniation (Fig. 1). Flexion-extension spine x-rays were performed and revealed no instability. A right lumbar L5-S1 transforaminal endoscopic foraminotomy and a discectomy were performed (Fig. 1). The patient had immediate relief of her radicular pain. At 2-year follow-up, her VAS and ODI improved from 6 and 36 to 2 and 28, respectively.

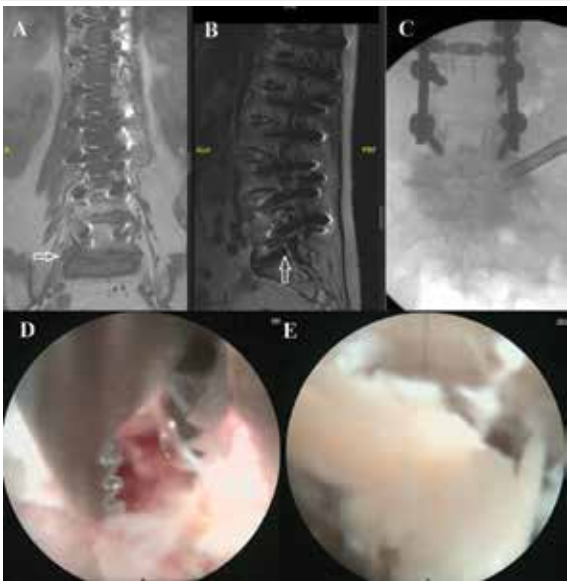

Fig. 1. *A right L5-S1 foraminal disc herniation below a T11-L5 fusion.* A. *Coronal and* B. *sagittal T2-weighted magnetic resonance image demonstrating the right L5-S1 foraminal disc herniation (open arrow) compressing the right L5 nerve.* C. *Anteroposterior fluoroscopic image demonstrating the beveled tubular retractor in the right L5-S1 foramen.* D. *Endoscopic camera view of the endoscopic grasper in the foramen.* E. *Endoscopic camera view of a large disc fragment in the tubular retractor.*

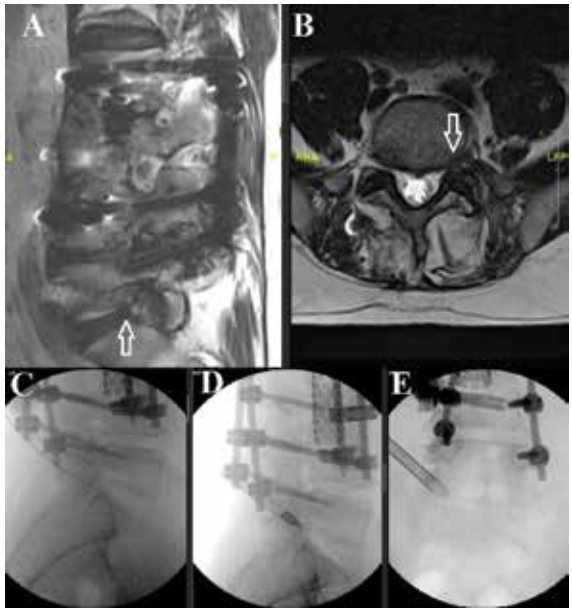

Fig. 2. *A left L5-S1 disc herniation below an L2-L5 fusion.* A. *Sagittal and* B. *Axial T2-weighted magnetic resonance images demonstrating the foraminal disc in the left L5-S1 foramen (open arrows).* C. *Lateral fluoroscopic image demonstrating the spinal needle accessing the left L5-S1 foramen and targeting the superior endplate of S1.* D. *Lateral fluoroscopic image of the tubular retractor inserted over the sequential dilators.* E. *Anteroposterior fluoroscopic image of the beveled tubular retractor in the left L5-S1 foramen.*

Case 2: A 38-year-old man presented after an L2-L5 fusion with a left L5 radiculopathy and left foot dorsiflexion weakness despite conservative treatment. An MRI demonstrated left L5 nerve compression in the left L5-S1 foramen (Fig. 2). A left L5-S1 transforaminal endoscopic discectomy and a foraminotomy were performed (Fig. 2). The patient had immediate relief of his radicular pain and significant improvement in his foot strength. At 2-year follow-up, his VAS and ODI improved from 7 and 48 to 1 and 26, respectively. His foot dorsiflexion strength also returned to normal.

Case 3: A 76-year-old man presented with left L5 radiculopathy after an L2-L5 fusion. An MRI demonstrated a left L5-S1 foraminal disc herniation compressing his left L5 nerve (Fig. 3). A left L5-S1 transforaminal endoscopic discectomy and a foraminotomy were performed (Fig. 3). At 2-year follow up, his VAS and ODI improved from 8 and 42 to 3 and 24, respectively.

Case 4: A 61-year-old man underwent an L4-L5 lateral fusion and, 9 months after his surgery, had right L5 radiculopathy. An MRI demonstrated a right L5-S1 foraminal disc herniation compressing his right L5 nerve (Fig. 4). He did not improve with conservative treatment. He elected to undergo a right L5-S1 transforaminal discectomy and foraminotomy (Fig. 4). At 2-year follow-up, his VAS and ODI improved from 8 and 10 to 2 and 4, respectively.

Case 5: A 62-year-old man underwent an L4-L5 fusion 5 years prior to presenting with right L5-S1 radiculopathy. An MRI demonstrated a right L5-S1 paracentral disc herniation (Fig. 5). Prior to proceeding with a right L5-S1 transforaminal endoscopic discectomy and foraminotomy (Fig. 5), the patient tried 6 months of nonoperative treatment that included physical therapy and interventional pain management. The patient presented with a preoperative VAS and ODI of 9 and 54 and only had 6 weeks of symptomatic relief after his endoscopic procedure. A follow-up MRI (Fig. 5) demonstrated a large right L5-S1 disc reherniation (Fig. 5) and the patient subsequently underwent a successful extension of his fusion (Fig. 5).

Discussion

Although substantial efforts have been made to

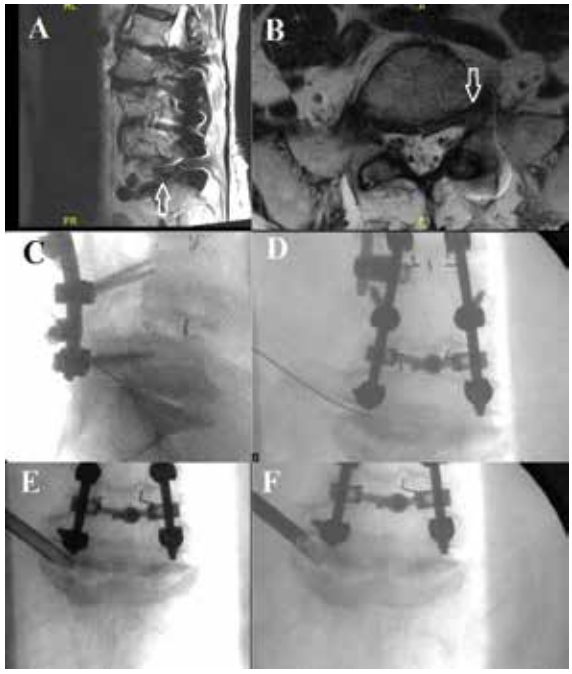

Fig. 3. *A left L5-S1 disc herniation below an L2-L5 fusion.* A. *Sagittal and* B. *Axial T2-weighted magnetic resonance images demonstrating the foraminal disc in the left L5-S1 foramen (open arrows).* C. *Lateral and* D. *anteroposterior fluoroscopic images demonstrating the spinal needle accessing the left L5-S1 foramen and targeting the superior endplate of S1 and the medial wall of the pedicle of S1.* D. *Lateral fluoroscopic image of the tubular retractor inserted over the sequential dilators.* E. *Anteroposterior fluoroscopic image of the beveled tubular retractor in the left L5-S1 foramen.* F. *Anteroposterior fluoroscopic image of the beveled tubular retractor in the left L5-S1 foramen with the endoscopic ball probe deployed.*

understand the etiology and risk factors of ASD after lumbar spine surgery, the incidence of this problem remains high and likely affects 20% of patients within 10 years of their index surgeries. For symptomatic patients who fail conservative management, open revision decompression and fusion is the standard surgical approach; however, percutaneous endoscopic decompression, which may offer select patients symptomatic relief with comparatively little risk, is an attractive potential alternative. In this series, we describe the management of 18 consecutive patients with symptomatic ASD at the L5-S1 segment with unilateral, minimally invasive endoscopic lumbar decompression surgery. One hundred percent of patients experienced immediate relief from their preoperative pain and 89% avoided subsequent surgical intervention at the 2-year mark. Patients in this

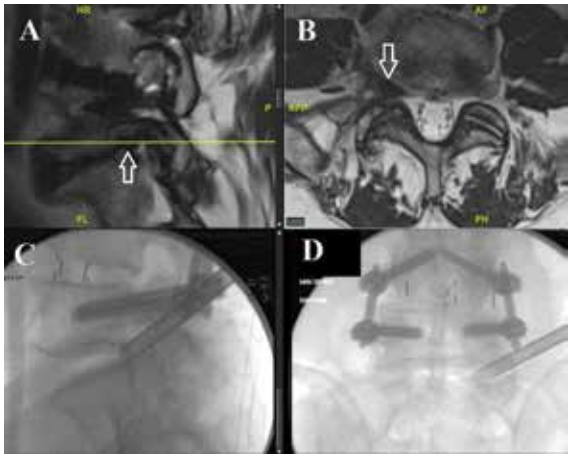

Fig. 4. *A right L5-S1 foraminal disc herniation below a L4-L5 lateral fusion.* A. *Sagittal and* B. *Axial T2-weighted magnetic resonance images demonstrating the foraminal disc in the right L5-S1 foramen (open arrows).* C. *Lateral and* D. *anteroposterior fluoroscopic images demonstrating the beveled tubular retractor in the right L5-S1 foramen.*

cohort demonstrated substantial declines in perioperative VAS and ODI scores. No major complications are reported.

The data presented in this series represent the largest described experience with endoscopic lumbar decompression to treat ASD at L5-S1 and contributes to a small but growing literature base on the application of such approaches to lumbar ASD. In an earlier series, Telfeian (corresponding author of the present series) (6) reported outcomes on 9 consecutive patients with lumbar ASD treated with endoscopic decompression, both rostral and caudal to their fusion constructs. Although initial results were following, 3 of 9 patients (33%) in the series required surgery at 2-year follow-up (6). Similarly, in a series of 13 patients, Iwai et al (7) also reported good short-term improvements in pain, though 3 of 13 patients ultimately required subsequent surgery. In a series of 15 patients with lumbar ASD, Kapetanakis et al (8) noted a nearly immediate improvement in VAS after surgery with a durable treatment effect notable even at one-year follow-up and no reported cases of failure requiring subsequent surgery. Notably, 12 of 15 patients who underwent endoscopic intervention in this study did so at the L5-S1 level (8). In a series of 25 patients over age 65 with ASD, Gu et al (9) reported that 84% of patients achieved excellent or good outcomes and that only 4% of patients required subsequent surgery. Notably, 3 complications (one

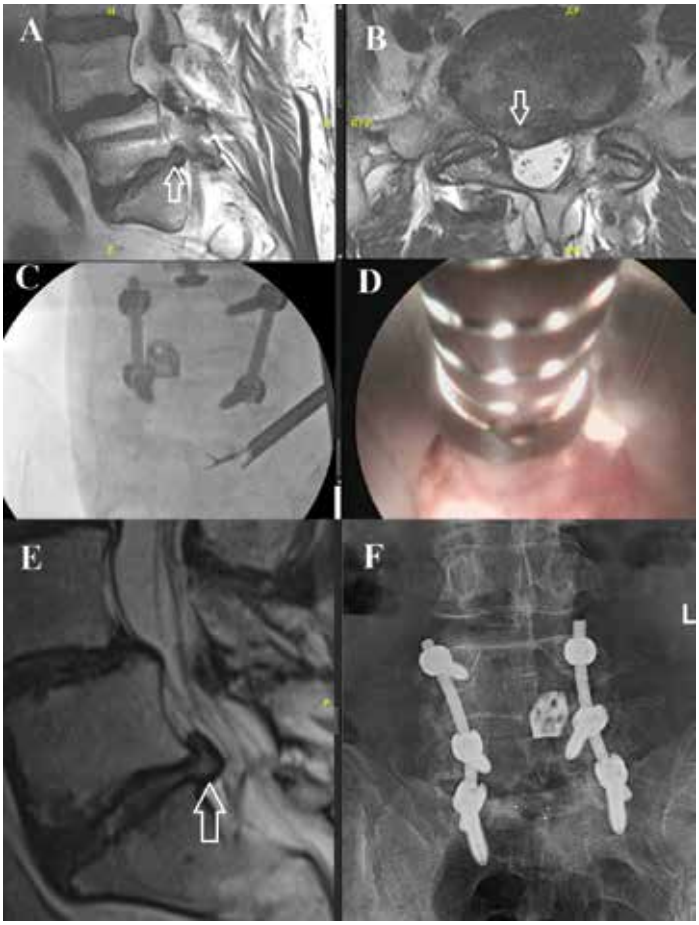

Fig. 5. *A right L5-S1 paracentral disc herniation below an L4-L5 transforaminal lumbar interbody fusion with recurrence after endoscopic decompression surgery. A. Sagittal and B. Axial T2-weighted magnetic resonance images demonstrating the paracentral disc in the right L5-S1 foramen (open arrows). C. Anteroposterior fluoroscopic image and D. endoscopic camera view demonstrating the semibendable grasper, endoscope, and beveled tubular retractor in the right L5-S1 foramen. E. Sagittal T2-weighted magnetic resonace image demonstrating the recurrent L5-S1 disc herniation (open arrow) 6 weeks after the endoscopic discectomy. F. Anteroposterior x-ray of the final L4-S1 fusion construct performed to treat the patient after his recurrent disc herniation.*

dural tear, one instance of new postoperative dysesthesia, and one treatment failure requiring subsequent surgery) were reported. In the largest published series of 33 patients undergoing endoscopic decompression for lumbar ASD, Ba et al (10) also reported satisfactory clinical outcomes in 83% of patients.

Direct comparisons in the established literature between endoscopic decompression and standard decompression with or without fusion is lacking. In their analysis, Ba et al (10) did find comparable clinical outcomes between percutaneous decompression and open decompression and fusion; however, it is unclear over what time period these outcomes were assessed. Furthermore, patients in the percutaneous decompression group had an average hospital stay of 2.73 days (10), which is largely inconsistent with the experience at our hospital, in which nearly all such patients are discharged home the same day. As previously noted, standard, open decompression alone is infrequently utilized for the treatment of ASD and specific assessments of this treatment approach are lacking. Schlegel et al (11) reported a series of 23 patients who underwent decompression alone for lumbar ASD; among these, only 15 (65%) achieved satisfactory outcomes. Of the remaining 8 patients, 7 underwent further revision surgery (11).

In general, for appropriately chosen patients, revision lumbar surgery for ASD is both efficacious and cost-effective, though the rates of cerebrospinal fluid (CSF) leak (6.7%) and estimated blood loss (712 mL) in one specific cohort of patients described by Adogwa et al (12,13) are both notable. Compared to patients who undergo percutaneous decompression and are discharged the same day, patients undergoing open surgery in this cohort had a mean length of stay of 4 days. Significant rates of CSF leak (5.3%), surgical site infection (3.3%), and discharge to rehabilitation (15.3%) have also been described in other large cohorts of patients undergoing revision lumbar surgery (14).

Revision surgery for ASD is already a cost-effective intervention; however, complications after surgery and/or readmissions can significantly detract from patient outcomes and increase the 2-year cost associated with surgical intervention in these patients (13,14). Rates of treatment failure, major complications, and/or inability to return to preoperative functional status after percutaneous endoscopic decompression, by contrast, remain quite low (15-18). If a majority of patients undergoing minimally invasive decompression achieve acceptable reductions in preoperative pain without associated complications or undue risk of failure requiring future

surgery, the cost-effectiveness of such an approach is quite evident. It is particularly notable that many of the patients in ours and other series that have undergone endoscopic decompression did so at the L5-S1 level. L5-S1, like many caudal adjacent segments, is classically thought to be at relatively low risk for the development of ASD, perhaps as a consequence of the relative immobility of the sacrum in relation to the fused lumbar spine (14,19). The relative stability of the L5-S1 segment, and its inaccessibility via other means such as the transpsoas approach for interbody fusion, may make L5-S1 ASD a pathology to which minimally invasive endoscopic decompression is uniquely well suited.

Although this is a small retrospective series, the outcomes described in this analysis reflect the results of patients operated on by a single surgeon at a single institution with a fixed surgical technique with 2-year follow up. Current understanding of ASD suggests that it is a progressive process; as such, it is likely that longer-term follow-up will be necessary to truly evaluate the efficacy of this treatment strategy. This study is also limited by selection bias of patients who returned to care and who were offered and decided to undergo this particular surgical intervention. The selection criteria for patients were limited to those patients suffering only from unilateral radicular pain. Patients treated either had extraforaminal, foraminal, or paracentral pathology that could be treated by a unilateral transforaminal approach. This study did not attempt to compare this intervention against other surgical or nonsurgical interventions for ASD. Future analyses, with multicenter and/or prospective designs, will likely be necessary to further assess the role of minimally invasive transforaminal decompression in this patient population.

Conclusion

Patients with symptomatic L5-S1 disc herniations below their fusion constructs typically only have revision fusion surgery as their only surgical option for treating their lumbar radiculopathy. A larger multicenter study with longer follow-up would be needed to evaluate whether transforaminal endoscopic spine surgery is truly a reasonable option for treating patients with radiculopathy below their fusion constructs. The case series presented here certainly indicates that a minimally invasive endoscopic approach for treating radiculopathy below a fusion may be a reasonable option for patients who are poor candidates for an extensive revision fusion surgery.

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