Transforaminal Percutaneous Endoscopic Surgery for Far Lateral Lumbar Intervertebral Disk Herniation

ZHONG LIAO, MD; WEI CHEN, MS; CHAO-HUI WANG, MS

Abstract

Far lateral lumbar intervertebral disk herniation (FLLIDH) most commonly occurs far lateral to the intervertebral facet at L3-L4 and L4-L5 and accounts for 3.8% of all lumbar disk herniations. Traditional surgery for FLLIDH involves massive surgical trauma, damage to the spinal structure, and instability of the lumbar spine. The goals of this study were to perform a systematic review of the literature and investigate the clinical outcomes of transforaminal percutaneous endoscopic surgery in the treatment of FLLIDH. Between October 2010 and May 2012, fifteen patients diagnosed with FLLIDH underwent transforaminal percutaneous endoscopic surgery at the authors’ institution to remove the herniated disk and release the nerve root. Pain was measured pre- and postoperatively with a visual analog pain scale (VAS), and postoperative outcomes were evaluated using MacNab’s criteria. A PubMed database search was conducted for the systematic review. Median operative time was 100 minutes (range, 80-140 minutes). Median volume of intraoperative blood loss was 20 mL (range, 10-50 mL). Patients were followed postoperatively for a median of 6 months (range, 1-12 months). MacNab’s criteria rated 12 (80.0%) surgical outcomes as excellent, 2 (13.3%) as good, and 1 (6.7%) as fair. The systematic review included 14 studies. Transforaminal percutaneous endoscopic surgery appears to be a safe and effective minimally invasive procedure for treating FLLIDH. However, as demand for this type of surgery increases, the possibility of intraoperative aggravated leg pain and compression injury of the ganglion must be considered.

Figure: Posteroanterior radiograph showing placement of the working tube.
Far lateral lumbar intervertebral disk herniation (FLLIDH) occurs far lateral of the intervertebral facet. It is caused by disk protrusion or extrusion inside or outside the foramen, which results in mechanical compression or subsequent inflammatory stimulation to the nerve root at the same level as the disk herniation. Far lateral lumbar intervertebral disk herniation differs from the classic, more medial disk herniation that compresses the nerve root at the level below. Up to 11% of lumbar herniated disks are FLLIDHs. Radicular symptoms typically occur.

Traditional surgical treatment for FLLIDH removes the nucleus pulposus via a transforaminal or intertransverse approach after removing the ipsilateral facet joint. This procedure involves extensive muscle dissection with massive surgical trauma, which may damage the spinal structure and cause lumbar spine instability. It is also associated with a high rate of injury in the dorsal branch of the nerve root, frequent incidence of muscle fibrosis and scarring, muscle atrophy, and myasthenic syndrome. Conservative treatments (ie, bed rest, physical therapy, oral steroidal and nonsteroidal anti-inflammatory drugs, or epidural steroid injections) may reduce or resolve symptoms in 70% to 80% of patients with more typical posterior or posterolateral disk herniation. However, these conservative measures are only successful in approximately 10% of FLLIDH cases; a long period of treatment is required, outcomes are often unsatisfactory, and surgery may finally become necessary.

Diskectomy is typically performed according to the disk herniation location. Many approaches have been used, including midline, intermuscular, extraforaminal, and paramedian. The individual patient’s pathology, such as the extent of stenosis and degenerative changes, may also influence the type of surgery required.

Interest is growing in less invasive procedures, such as foraminal and transforaminal endoscopic techniques using endoscopic spine systems and microendoscopic discectomy (MED), which uses a posterior approach rather than transforaminal. Microendoscopic discectomy was reported to be at least as effective as microsurgical discectomy for treating uncontained or large, contained disk herniations, but without significant advantages. A recent review of 39 studies assessing the effectiveness of transforaminal endoscopic surgery for symptomatic lumbar disk herniations found no significant differences in pain, overall improvement, patient satisfaction, recurrence rates, and complications between transforaminal endoscopic surgery and open microdiscectomy. There is a lack of evidence to determine the effectiveness of endoscopic surgeries compared with open microdiscectomy for symptomatic lumbar disk herniations, including FLLIDHs. At the same time, few studies have specifically explored the feasibility of percutaneous endoscopic lumbar diskectomy for FLLIDH. The purpose of this prospective study of 15 cases was to conduct a systematic review of the literature and investigate the clinical outcomes of minimally invasive transforaminal percutaneous endoscopic surgery in the treatment of FLLIDH.

**Surgical Technique**

Local anesthesia was used. Patients were informed that discomfort and pain may be felt during surgery. A radiolucent operating table and C-arm machine were used. A solution of 3000 mL saline plus 80 mg gentamicin plus 0.5 mg epinephrine was prepared for intraoperative continuous infusion.

The patient was placed in the lateral recumbent position on the operating table. Appropriate patient position and accurate design of the route from the skin to the herniated disk are key for excellent surgical outcomes. The patient was given selective local anesthesia using lidocaine with different concentrations for various layers. Aspiration localization was determined based on disk level; for example, when performing an operation at the L5-S1 level, the entering point should be 12 to 16 cm from the posterior midline at the L5 spinous process level. The aspiration angle should be 15° to 25° from the posterior midline level.
horizontal plane. The ideal location of the needle tip is close to the line connecting the pedicle centers under anteroposterior fluoroscopy and on the line connecting the posterior margins of adjacent vertebral bodies and the anterior upper margin of the upper process of S1 facet joint under lateral fluoroscopy. Provocative diskography was performed fluoroscopic guidance. A #18 aspiration needle was inserted into the disk space through the foramen, the core was removed, and contrast agent (iohexol:methylene blue=3:1) was injected slowly into the intervertebral disk. To evaluate pain provocation, the patient was asked whether low back pain or radiating pain was present.

A guidewire was placed into the intervertebral disk through the aspiration needle, then the needle was removed. A skin incision 7 to 8 mm in diameter was made around the guidewire. A dilator 2 mm in diameter was inserted along the guidewire, then dilators 3.5, 4.5, and 5.5 mm in diameter were inserted one by one to expand the surgical pathway. The foramen below the nerve root was not expanded with a circular saw. A working tube 7.5 mm in diameter was inserted into the intervertebral disk, and an endoscope was placed within (Figure). Various tissues were identified under continuous irrigation, and partial decompression was performed using Yeung’s method. The endoscope was then withdrawn outside the foramen to expose the target disk tissue. The degenerated nucleus pulposus was found, and the exiting nerve root was protected. The nerve root was fended off with the working tube. Protruded, extruded, or sequestrated nucleus pulposus tissues were cut off and removed with pituitary forceps and pituitary scissors of varying types with varying angles; the nerve root was explored and released. Finally, ablation decompression and annuloplasty were performed using bipolar radiofrequency.

The disk, epidural fat, posterior longitudinal ligament, and nerve root were carefully checked before surgery completion. The endoscope and working tube were taken out, and the skin incision was closed after provocation tests (eg, straight-leg raising test) became negative, muscle power increased, and sensory disturbance (eg, numbness) was relieved. The wound was dressed, and generally no drainage was applied.

Postoperative Management

If intraoperative bleeding occurred, a drainage tube was placed for 12 hours. If neural disturbance was noted, a small amount of betamethasone was injected into the operative site before removing the working tube to prevent nerve swelling. Antibiotics were given 1 to 3 days postoperatively to prevent infection. Patients were able to walk with a waist brace after 1 to 3 days of bed rest and were then discharged. However, heavy lifting was prohibited. Lower-extremity activities, including straight-leg raising test, were encouraged. Mannitol and dexamethasone were used for 1 day to reduce nerve root swelling. After 1 day of bed rest, patients were allowed to use the bathroom with the protection of a waist brace. Normal work and activities of daily living were permitted 3 to 4 weeks postoperatively.

Outcome Evaluation

Visual analog scale scores and median muscle power grades were measured pre- and postoperatively and at last follow-up. Muscle power grades ranged from 0 to 5, with 0 representing complete paralysis; 1, visible muscle movement; 2, moves but cannot oppose gravity; 3, moves and can oppose gravity; 4, weakness but some resistance; and 5, normal muscle power. Criteria were applied as follows to evaluate surgical outcomes: excellent indicates no pain and no restriction of movement, allowing the patient to work normally; good indicates occasional pain, allowing the patient to work normally; fair indicates slight progress; and poor indicates no progress.

Statistical Analysis

Data were presented as median with range for continuous variables and as frequency with percentage for categorical variables. Differences in patients’ VAS scores and muscle power grades at different operative stages (postoperative vs preoperative and last follow-up vs preoperative) were detected using Wilcoxon’s signed rank test. All statistical analyses were performed with SAS software version 9.2 (SAS Institute Inc, Cary, North Carolina). A 2-tailed P value less than .05 indicated statistical significance.
The PubMed database was searched using the following search terms and combinations of search terms: transforaminal percutaneous endoscopic surgery, far lateral lumbar intervertebral disk herniation, extraforaminal lumbar intervertebral disk herniation, lumbar disk herniation, transforaminal percutaneous endoscopic surgery AND far lateral lumbar intervertebral disk herniation, lumbar disk herniation AND transforaminal percutaneous endoscopic surgery. Studies published up to May 2013 were included.

Studies were eligible for the systematic review if they were prospective studies, retrospective comparison studies, case study/case series, or technical case reports and if percutaneous endoscopy was used as a surgical procedure. Studies were excluded if they did not use a VAS or MacNab’s criteria to assess outcome.

RESULTS

Summary of Patient Outcomes

Median operative time was 100 minutes (range, 80-140 minutes). Median volume of intraoperative blood loss was 20 mL (range, 10-50 mL). Patients were followed for a median of 6 months postoperatively (range, 1-12 months). There was 1 complication, a case of leg numbness caused by ganglion injury. This patient was treated with betamethasone 4 mg, which was injected transfarminally. The leg areas with numbness were treated for 1 month with middle-frequency electrotherapy. Subsequently, there was complete recovery of muscle power and motor function in the legs. The ganglionic injury may not have affected motor function. The numbness improved after 2 weeks. After 3 months, it was obvious that the total area of numbness in the legs had become smaller. At last follow-up, the patient had no pain, and only a few areas with numbness remained and did not affect the patient’s activities of daily living. MacNab’s criteria rated 12 (80.0%) surgical outcomes as excellent,
Improvement in Visual Analog Scale Scores and Muscle Power

Median VAS scores were 7.5 (range, 6.0-9.0), 3.0 (range, 1.0-5.0), and 1.5 (range, 0.5-3.0) preoperatively, postoperatively, and at last follow-up, respectively (Table 2). Both postoperative (median difference, -4.5 [range, -7.5, to -1.5]; P=0.0001) and last follow-up (median difference, -6.0 [range, -7.5, to -4.5]; P=0.0001) VAS scores were significantly different compared with preoperative VAS scores, representing significant postoperative improvement in pain levels.

Median muscle power grades were 3.0 (range, 3.0-4.0), 4.0 (range, 4.0-5.0), and 5.0 (range, 4.5-5.0) preoperatively, postoperatively, and at last follow-up, respectively (Table 2). Both postoperative (median difference, 1.0 [range, 0.0-2.0]; P=0.0005) and last follow-up (median difference: 2.0 [range, 0.5-2.0], P=0.0001) muscle power grades were significantly different compared with preoperative grades, representing significant postoperative improvement in muscle power.

Systematic Review

A total of 111 articles were found during the systematic review. Fourteen articles met the selection criteria. The results of the systematic review are shown in Table 3. The 14 studies included 1695 patients with disk herniation. More than half of the patients were included in 1 study, which was a retrospective study of 915 patients. Among the 14 studies, 10 were prospective and 4 were retrospective. The duration of follow-up ranged from 3 to 38.8 months in the 10 studies that provided duration of follow-up data. In 3 studies, the duration of follow-up was 18 months, whereas the rest of the studies reported different follow-up times. Among the 10 studies that provided data on outcomes in terms of excellent, good, fair, or poor, 9 studies reported excellent or good outcomes for more than 80% of the patients.

Discussion

Outcomes of the 15 patients with FLLIDH who received minimally invasive transforaminal percutaneous endoscopic surgery were all satisfactory, including 12 (80.0%) excellent outcomes, 2 (13.3%) good outcomes, and 1 (6.7%) fair outcome. Operative times were good (range, 80-140 minutes), intraoperative blood loss was low, and only 1 patient had a complication: postoperative leg numbness due to ganglion injury. Patients experienced significant postoperative improvement in pain levels and muscle power. Only minimal surgical effects on the intervertebral disk were observed, and lumbar spine stability was not affected in any patient. The small incision permitted use of local anesthesia, which maximally decreased the potential damage that can occur with general anesthesia.

Transforaminal endoscopic discectomy can directly remove spinal lesions through the safe triangular working zone, successfully decompress the nerve root, and effectively reduce spinal tissue damage. Together, minimal internal tissue damage and a smaller surgical incision (approximately 7 mm) reduces the revalidation period, minimizes scar tissue, and reduces complications. Intraoperative bleeding is reduced, and hemostasis can be expected postoperatively. It encourages fast wound healing and reduces the risk of infection.

The traditional translaminar approach cannot achieve satisfactory decompression because FLLIDH is outside the spinal canal. Moreover, it interferes with the environment inside the spinal canal, precluding improvement of the original symptoms postoperatively. Adhesion, scar compression, and dura mater fibrosis often occur postoperatively, which may lead to related symptoms. The required resection of spinal canal structures leads to operation-induced destabilization. Removing the herniated disk via the transarticular approach may cause segmental instability and aggravate low back pain, often requiring simultaneous spinal fusion in the related segment.

In the current series, all patients had simple FLLIDH, including 1 in seg-
Table 3

<table>
<thead>
<tr>
<th>Author</th>
<th>Study Design</th>
<th>No. of Patents</th>
<th>Surgical Procedure</th>
<th>Levels of Surgery</th>
<th>Follow-up, mo</th>
<th>Visual Analog Pain Scale</th>
<th>MacNab's Criteria</th>
<th>Comments</th>
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<tr>
<td>Lew et al⁵</td>
<td>Retrospective</td>
<td>47</td>
<td>Transforaminal percutaneous endoscopic discectomy</td>
<td>L1-L2 (n=2), L2-L3 (n=4), L3-L4 (n=19), L4-L5 (n=21), L5-S1 (n=1)</td>
<td>18</td>
<td>-</td>
<td>Excellent or good (n=40; 85%)</td>
<td>Five (11%) patients had poor outcomes and subsequently underwent open procedures at the same level. Of 10 recipients of workers’ compensation, MacNab’s criteria indicated a significantly worse outcome (70% excellent or good), but an excellent return-to-work status was maintained (90%).</td>
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<tr>
<td>Sasani et al¹</td>
<td>Prospective</td>
<td>66</td>
<td>Percutaneous endoscopic discectomy</td>
<td>L2-L3 (n=5), L3-L4 (n=19), L4-L5 (n=42)</td>
<td>-</td>
<td>Preop, 8.2; postop (7 d), 4.2; postop (6 mo), 1.4; postop (12 mo), 1.2 (P&lt;0.05)</td>
<td>-</td>
<td>In 2 patients (1 L4-L5 and 1 L3-L4), disk material could not be removed with posterolateral endoscopic discectomy, so discectomy was performed with microscopic visualization during the same session. Three patients (L4-L5) were reoperated on 3 to 6 mo after initial surgery due to recurring disk problems with microscope visualization. In 2 patients (L4-L5), root nerves were partially damaged, and in 2 others (L4-L5), root nerves were impinged by the working channel. These 4 patients had dysesthesias from immediately postoperatively to a mean of 45 d postoperatively. One of these patients had a recurrent case. Neurological examination showed minimal muscle weakness of the quadriceps femoris and diminished sensation of the L4 dermatomal area with partial nerve root damage. This patient improved, and neurologic examination became normal with disappearance of the dysesthesia. There was no sign of reflex sympathetic dystrophy.</td>
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<tr>
<td>Lubbers et al⁶</td>
<td>Prospective</td>
<td>22</td>
<td>Percutaneous endoscopic lumbar discectomy of lateral and far lateral disk herniations</td>
<td>L5-S1</td>
<td>-</td>
<td>Preop, 88.6±7.6 (8.86); postop (2 d), 28.6±22.8 (2.86); postop (3 wk), 40.5±22.8 (4.05); postop (6 mo), 34.3±25.1 (3.43); last follow-up, 32 (3.2)</td>
<td>Excellent or good (n=18; 81.8%), fair (n=3; 13.6%), poor (n=1; 4.5%)</td>
<td>At follow-up, 2 (9.1%) patients had recurrent disk herniations that were corrected with open surgery. Postoperatively, 1 patient could not return to his original job because of a comorbidity.</td>
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<tr>
<td>Author</td>
<td>Study Design</td>
<td>No. of Patients</td>
<td>Surgical Procedure</td>
<td>Levels of Surgery</td>
<td>Follow-up, mo</td>
<td>Visual Analog Pain Scale</td>
<td>MacNab’s Criteria</td>
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<td>Ahn et al&lt;sup&gt;14&lt;/sup&gt;</td>
<td>Prospective</td>
<td>45</td>
<td>Percutaneous endoscopic discectomy (posterolateral transforaminal endoscopic laser-assisted disk removal)</td>
<td>L1-L2, L2-L3</td>
<td>38.8</td>
<td>Preop, 8.38; postop, 2.36 (P&lt;.0001)</td>
<td>-</td>
<td>Three patients (8.6%) experienced persistent radiculopathy and subsequently underwent open microdiscectomy at the same level.</td>
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<td>Jang et al&lt;sup&gt;15&lt;/sup&gt;</td>
<td>Prospective</td>
<td>35</td>
<td>Posterolateral endoscopic discectomy (intraforaminal or extraforaminal)</td>
<td>L2-L3, L3-L4, L4-L5, L5-S1</td>
<td>18</td>
<td>Preop, 8.6; postop, 3.2 (P&lt;.01)</td>
<td>Excellent or good (n=30; 85.7%) (P&lt;.01)</td>
<td>Ninety-six patients were found with permanently ameliorated or normal clinical status after endoscopy alone. The remaining 26 patients with unchanged or only temporarily improved neurological disorders underwent conventional microsurgical interventions. Spinal nerve root injury during endoscopic treatment occurred in 2 patients, but no additional neurological deficits or aggravation of pre-existing disorders were observed.</td>
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<tr>
<td>Eustacchio et al&lt;sup&gt;16&lt;/sup&gt;</td>
<td>Prospective</td>
<td>122</td>
<td>Endoscopic percutaneous transforaminal</td>
<td>L2-L3 (n=1), L3-L4 (n=30), L4-L5 (n=74), L5-L6 (n=6), L5-S1 (n=15)</td>
<td>35</td>
<td>-</td>
<td>Excellent or good, 77.9%; excellent (n=60; 49.2%); good (n=35; 28.7%); fair (n=1; 8.8%); poor (n=0; 0%)</td>
<td>Ninety-six patients were found with permanently ameliorated or normal clinical status after endoscopy alone. The remaining 26 patients with unchanged or only temporarily improved neurological disorders underwent conventional microsurgical interventions. Spinal nerve root injury during endoscopic treatment occurred in 2 patients, but no additional neurological deficits or aggravation of pre-existing disorders were observed.</td>
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<td>Bai et al&lt;sup&gt;17&lt;/sup&gt;</td>
<td>Prospective</td>
<td>119</td>
<td>Diskography and transforaminal endoscopic surgery</td>
<td>L2-L3 (n=3), L3-L4 (n=6), L4-L5 (n=88), L5-S1 (n=22)</td>
<td>26.1</td>
<td>Preop, 6.8; postop, 1.8 (P&lt;.05)</td>
<td>Excellent or good (85.6%), excellent (n=82; 68.9%); good (n=20; 16.7%); fair (n=8; 6.7%); bad (n=9; 7.7%)</td>
<td>One patient had L5 nerve root injury complicated with paresthesia and weakness of the affected lower extremity, which was gradually relieved after conservative treatment for over 3 mo. Another patient with postoperative intradiskal infection was referred to another institution and lost to follow-up thereafter. Five patients had no improvement 6 mo after the first surgery and were reopened on endoscopically.</td>
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<td>Choi et al&lt;sup&gt;18&lt;/sup&gt;</td>
<td>Clinical trial</td>
<td>67</td>
<td>Percutaneous endoscopic discectomy through the interlaminar approach</td>
<td>L5-S1</td>
<td>18</td>
<td>Preop, 7.89; postop, 1.58</td>
<td>-</td>
<td>Two cases of dural injury with cerebrospinal fluid leakage, 9 cases of dysesthesia that were transient, and 1 case of recurrence. Two patients required conversion to an open procedure at the initial operation.</td>
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<tr>
<td>Ahn et al&lt;sup&gt;19&lt;/sup&gt;</td>
<td>Retrospective</td>
<td>43</td>
<td>Percutaneous endoscopic lumbar discectomy</td>
<td>L3-L4, L4-L5, L5-S1</td>
<td>31</td>
<td>Preop, 8.72±1.20; postop, 2.58±1.55 (P=.0001)</td>
<td>Excellent or good, 84.4%</td>
<td>Better outcomes were obtained in patients younger than 40 y (P=.035), patients with symptom duration of less than 3 mo (P=.028), and patients without concurrent lateral recess stenosis (P=.007).</td>
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### Table 3 (cont’d)

**Results of Systematic Review**

<table>
<thead>
<tr>
<th>Author</th>
<th>Study Design</th>
<th>No. of Patients</th>
<th>Surgical Procedure</th>
<th>Levels of Surgery</th>
<th>Follow-up, mo</th>
<th>Visual Analog Pain Scale</th>
<th>MacNab’s Criteria</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kim et al&lt;sup&gt;20&lt;/sup&gt;</td>
<td>Retrospective comparison</td>
<td>915</td>
<td>Percutaneous transforaminal endoscopic discectomy (group A=295 patients) or microscopic discectomy (group B=607 patients)</td>
<td>L1-L2, L2-L3, L3-L4, L4-L5, L5-S1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Twenty-eight patients (14 cases of recurrence, 5 cases of incomplete removal, 5 cases of stenosis, 2 cases of diskogenic back pain, and 2 cases of diskitis) in group A and 38 patients (26 cases of recurrence, 6 cases of incomplete removal, 2 cases of stenosis, 2 cases of diskogenic back pain, 1 case of hematoma, and 1 case of diskitis) in group B underwent reoperation.</td>
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<tr>
<td>Tzaan&lt;sup&gt;21&lt;/sup&gt;</td>
<td>Retrospective</td>
<td>142</td>
<td>Transforaminal posterolateral endoscopic discectomy alone or combined with an intradiskal injection of low-dose (1000 U) chymopapain</td>
<td>L5-S1 (n=37), L4-L5 (n=106), L3-L4 (n=13), L2-L3 (n=7)</td>
<td>8</td>
<td>-</td>
<td>-</td>
<td>Six (4.5%) patients underwent open surgery later. Eight (6%) patients sustained temporary dysesthesia over the proximal lower limb of the operated on side.</td>
</tr>
<tr>
<td>Hirano et al&lt;sup&gt;22&lt;/sup&gt;</td>
<td>Prospective/technical report</td>
<td>37</td>
<td>Percutaneous endoscopic lumbar discectomy (transforaminal, interlaminar, or extrafornaminal approach)</td>
<td>L4-L5, L5-S1, L2-L3, L3-L4, L1-L2</td>
<td>3</td>
<td>Preop, 7.58; postop, 0.97</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kim et al&lt;sup&gt;23&lt;/sup&gt;</td>
<td>Prospective/technical report</td>
<td>10</td>
<td>Percutaneous endoscopic interlaminar discectomy</td>
<td>L5-S1 (n=5), L4-L5 (n=4), L2-L3 (n=1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Recurrence occurred in 1 patient 1 y postoperatively.</td>
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</table>
In addition, access to the herniated disk within the spinal canal can be difficult. Also, when the lateral approach is used, excision of dislocated herniated material can be constrained by the bony foramen perimeter and the exiting nerve. In addition, access can be impeded by the pelvis and abdominal structures.

There have been a number of studies on the outcomes of using endoscopic surgery to treat patients with FLLIDH. Forty-five patients with soft disk herniation at L1-L2 and L2-L3 underwent percutaneous endoscopic discectomy, and 46.7% had good outcomes, 31.1% had good outcomes, 13.3% had fair outcomes, and 8.9% had poor outcomes. The investigators emphasized patient selection as key to successful surgery.

A retrospective analysis of minimally invasive endoscopic surgery for FLLIDH reported the procedure to be safe and efficacious, although complications included 2 cases of incidental dural tear without cerebrospinal fluid leakage and 1 residual sequestered disk that required repeat discectomy.

In another study of 66 patients with FLLIDH, percutaneous endoscopic discectomy was successfully performed, removing fragmented disk material and relieving pain in all patients, although 3 patients required repeat discectomy. The authors emphasized the benefits of the surgical technique but cautioned that extensive surgical practice is needed and that the technique is only applicable to selected patients.

When transfemoral endoscopic discectomy was applied for recurrent herniation, the method was considered effective, with reduced recurrence in 2-year follow-up, few complications, and high patient satisfaction. However, in a review of 8 clinical trials, no statistically significant differences were found in leg pain reduction, overall patient improvement, or complication rates between transfemoral endoscopic surgery and open microdiscectomy. High-quality randomized, controlled trials with large samples are still needed to determine whether transfemoral endoscopic surgery is more effective than open microdiscectomy for FLLIDH.

In a prospective study, percutaneous endoscopic discectomy with the new foraminal retreat technique was used to treat 22 patients with lateral or far lateral disk herniations. The outcome at last follow-up was excellent or good in 81.8% of patients. In another prospective study, percutaneous endoscopic discectomy was used to treat 35 patients with foraminal or extraforaminal lumbar disk herniations.
At a mean follow-up of 18 months, 85.7% of patients had good or excellent outcomes. The authors emphasized the importance of proper patient selection when performing this procedure. In a retrospective study, 47 consecutive patients with far lateral and foraminal lumbar disk herniations underwent endoscopic surgery. At a median follow-up of 18 months, 85% of patients had excellent or good outcomes.

In the current authors’ study, 1 patient had leg numbness due to ganglion injury, and the systematic review showed that nerve root injury can be a serious complication when endoscopic transforaminal endoscopic discectomy is performed. Sasani et al3 reported 2 patients with partially damaged nerve roots and 2 patients with root nerves impinged by the working channel, Eustacchio et al139 reported nerve root injury in 2 patients, and Bai et al37 reported a patient with L5 nerve root injury complicated by paresthesia and weakness of the affected lower extremity. Choi et al18 reported 2 patients who had dural injury with cerebrospinal fluid leakage.

The current authors’ experience suggests that the following measures may help prevent nerve root injury when performing transforaminal endoscopic discectomy for FLLIDH:

1. Local anesthesia should be used so that patients can inform the surgeon about lower-extremity pain or numbness when the nerve root is touched. Patients should be informed about this preoperatively.

2. Skilled endoscopic hemostasis should be applied for maintaining a clear operative field. Manipulation in a pool of blood should be avoided to prevent nerve root injury.

3. Yeung’s technique9,13 should be applied to insert the working tube into the intervertebral disk through the safe triangular working zone for partial decompression. The working tube should be withdrawn to the exit of the foramen for exploration and direct nerve root decompression. Use of Tsou’s technique35 should be avoided; the working tube should not be inserted by force into the spinal canal through the foramen. Application of circular saws should also be prohibited to prevent exiting nerve root injury.

4. When exploring or removing herniated disks located medially to the nerve root, the nerve root should be managed gently to avoid severe pain and ganglion injury, which aggravates lower-extremity numbness and delays symptom relief.

5. Nerve root compression in FLLIDH is concentrated and localized, which relatively increases pressure-inducing stimulation. Nerve root decompression can be achieved by partially removing the herniated disk tissue. Overdisturbing the nerve root should be avoided to prevent nerve injury and subsequent numbness. In the authors’ cases, even if disk herniation was seen on postoperative computed tomography, no symptoms remained post-operatively. The authors encountered 1 other patient with FLLIDH at L4-L5 who had quadriceps atrophy. The symptom resolved suddenly before surgery, which had been temporarily delayed due to meninges. The authors speculated that it was relieved because the nerve root shifted from the pointed end of the herniated disk.

6. If numbness and discomfort recur at the affected side intra- or postoperatively, ganglion injury should be considered and local nerve root block applied.

Interpretation of the current study’s results is limited by the small sample. Although the majority of the authors’ patients had good to excellent outcomes with resolution of symptoms and restored function, the authors did not evaluate patient satisfaction, and follow-up time varied (median, 6 months). Future prospective study with a larger sample and extended follow-up is needed to confirm outcomes of minimally invasive transforaminal percutaneous endoscopic treatment for FLLIDH and evaluate long-term efficacy.

**CONCLUSION**

Transforaminal percutaneous endoscopic surgery appears to be a feasible minimally invasive procedure for treating FLLIDH. It can be performed under local anesthesia, has no significant influence on the intervertebral disk, does not affect lumbar stability, results in few complications, and is economically feasible. As demand for this surgery continues to increase, the possibility of intraoperative aggravation of leg pain and compression injury of the ganglion must be considered.

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