

# Foraminoplastic Ventral Epidural Approach for Removal of Extruded Herniated Fragment at the L5-S1 Level

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## Abstract

The 'foraminoplastic' ventral epidural approach and its advantages in the treatment of extruded disk herniation at the L5-S1 level are described. Percutaneous endoscopic lumbar discectomy is a minimally invasive procedure applicable to various types of lumbar disk herniation, but the L5-S1 disk space is still challenging to access due to anatomic limitations such as high iliac crest or severely narrowed foramen. The 'foraminoplastic' ventral epidural approach was performed in 25 patients with herniated disk radiculopathy at L5-S1 from March 2003 to May 2004. Their mean age was 39.2 years (range 20-67 years) and the mean follow-up duration was 32.5 months (range 28-42 months). During the procedure, 'foraminoplasty' was performed by undercutting the hypertrophic superior facet with the endoscopic bone cutter under C-arm guidance. The clinical result was assessed according to the visual analogue scale (VAS) and Oswestry disability index (ODI). Preoperative mean VAS score of 7.4 for leg pain fell to 1.6 postoperatively and mean preoperative ODI of 55.5% improved to 16.9% postoperatively, both showing significant improvements ( $p < 0.001$ ). Mean hospital stay was 14.2 hours. Twenty-two patients had the favorable outcomes. Two patients required conversion to open microdiscectomy due to incomplete decompression and recurrent disk herniation. The 'foraminoplastic' approach is a safe and efficient surgical option for L5-S1 disk herniation even in patients with high iliac crest and narrow foramen.

Key words: foraminoplastic approach, L5-S1, high iliac crest, narrow foramen, endoscopic discectomy

## Introduction

Percutaneous endoscopic lumbar discectomy (PELD) has become well known since posterolateral percutaneous lumbar disk decompression was first introduced in 1983,<sup>10</sup> and numerous studies have reported successful endoscopic procedures for various lumbar spinal pathologies including lumbar disk herniation.<sup>2,8,14,15,19</sup> Endoscopic surgery has several advantages compared to open surgery, such as less injury to the paraspinal muscle and the normal tissue, and more rapid recovery. However, endoscopic treatment may be difficult to perform in the presence of anatomical limitations at the L5-S1 level, such as high iliac crest or narrow foramen.<sup>16,17</sup> Therefore, surgeons have preferred to perform open lumbar microdiscectomy (OLM) instead of PELD. However, various endoscopic surgical options have

been developed to overcome anatomical limitations.

The present study describes the technique of the 'foraminoplastic' ventral epidural approach at the L5-S1 level to overcome such limitations.

## Materials and Methods

A retrospective review was performed of 25 consecutive patients, 15 men and 10 women aged 20-67 years (mean 39.2 years) with extruded disk herniation at the L5-S1 level who underwent decompression by the 'foraminoplastic' approach between March 2003 and May 2004. The mean hospital stay was 14.2 hours (range 4-36 hours). The inclusion criteria were as follows: extruded soft disk herniation producing radiating pain, high iliac crest or narrow foramen hindering approach to the L5-S1 level, no spinal stenosis, and no response to conservative treatment. Patients with radiculopathy caused by spinal stenosis, posterior pathology caus-

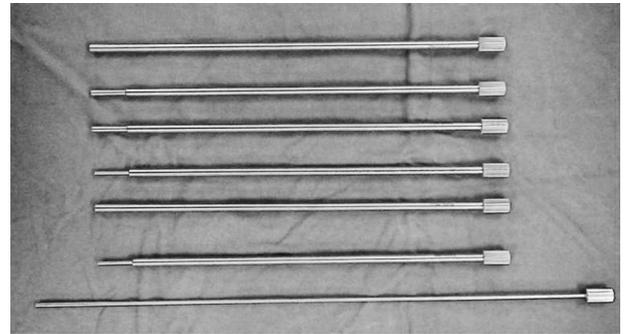
ing radicular symptoms, and calcified disk were excluded.

The clinical outcomes were assessed using the visual analog scale (VAS) for leg pain and Oswestry disability index (ODI). One author (Y.A.), who was unaware of the clinical details, examined pre- and postoperative neuroimaging findings. Statistical analysis was performed using the paired *t*-test and Wilcoxon's signed rank test. P value less than 0.05 was considered significant. The mean follow-up period was 32.5 months (range 28–42 months).

Preoperative dose of prophylactic antibiotic was administered. The patient was placed prone on a radiolucent operating table in the conscious state under local anesthesia. The imaginary line drawn to the fragment through the foramen designated the early point and the surgical trajectory. According to this guideline, the skin entry point was approximately 8 to 11 cm apart from the midline in Korean patients. Under fluoroscopic guidance, an 18-gauge-long needle was inserted into foramen and the outer surface of the annulus and 1–1.5 cm<sup>3</sup> (less than 2 cm<sup>3</sup>) of lidocaine was injected. A guide wire was inserted through the needle channel. After removal of the needle, a tapered cannula obturator was slid over the guide wire to the posterolateral margin of the facet. A beveled working cannula was introduced along the obturator, surrounding the superior facet and leaning against the root, which is safe. A 5-mm or 7-mm bone cutter (Arthro Kinetics PLC, Park Green, Macclesfield, U.K.) was then inserted through the working cannula depending on the amount of bone to be removed (Fig. 1). Using the bone cutter, the lateral aspect of the superior facet was undercut, and the foraminal annulus was cut simultaneously (Fig. 2A). This procedure of bone cutting used a twisting motion involving moderate amount of force and under constant fluoroscopic control to prevent damage to the facet joint.

The endoscopic bone cutter could be advanced safely through the working cannula until the medial pedicular line was reached on the fluoroscopic anteroposterior view (Fig. 2B). In addition, as the endoscopic-bone cutter is advanced, blood loss is prevented since the endoscopic-bone cutter pushed the resected bony fragment into the location of the venous sinus channel, so naturally blocking the sinus inducing natural homeostasis.

The foramen was then enlarged enough for 'foraminoplasty' (Fig. 2C). The serrated end of the reamer did not pass beyond the medial border of the facet joint to avoid neural injury on model, axial, and sagittal magnetic resonance (MR) imaging, respectively (Figs. 3–5). Then an obturator was introduced into the disk space working sheath and ta-



**Fig. 1** Photograph showing endoscopic bone cutters. These devices are cylindrical hollow instruments with a sharp serrated working end in 3 mm, 5 mm, and 7 mm sizes used for undercutting the superior facet or removal of part of the vertebral body.



**Fig. 2** Schematic drawings of the 'foraminoplastic' approach. **A:** Beveled cannula is facing the superior facet before cutting. **B:** Cutting the superior facet with the endoscopic bone cutter surrounded by the cannula up to the medial pedicular line. **C:** Widened foramen after foraminoplasty.

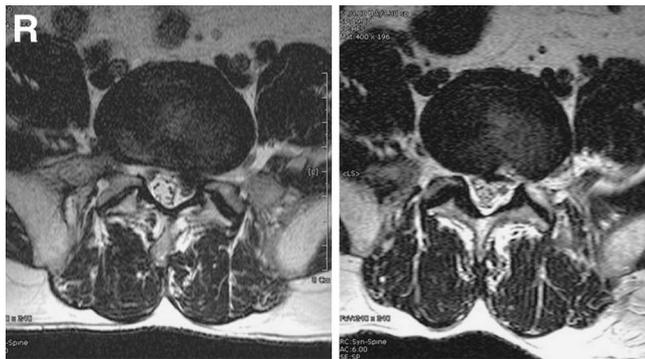
pered again to observe the intradiscal portion. An 18-gauge-long needle was inserted along the guide wire to introduce disk space. Intraoperative discography was performed to determine the pathology.

Before the needle was withdrawn, a guide wire was inserted to introduce the serial dilation and obturator. The working sheath was introduced through the obturator. Every step of decompression was done under direct endoscopic view. The blue-stained annular surface and part of the disk material could be observed under endoscopic visualization (Fig. 6).

To access the herniated fragment, widening of the side hole of annular fissure was necessary. Therefore, with the side firing laser and a bipolar radio frequency (Elliquance®; Elliquance International Inc., N.Y., U.S.A.), enough space was gained under excess saline irrigation. Then, using the endoscopic forceps, sufficient annulectomy was performed. The blue-stained herniated mass could be seen. With the side-firing laser, the superior and inferior slopes of



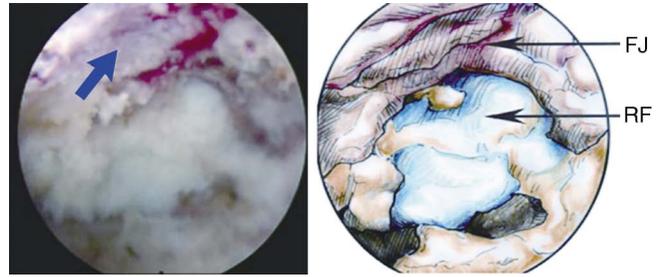
**Fig. 3** Model showing the position of the endoscopic bone cutter on the undersurface of the superior facet. The cutter does not violate the facet joint.



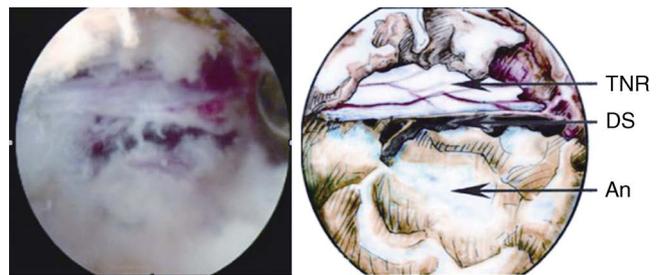
**Fig. 4** Pre- (left) and postoperative (right) T<sub>2</sub>-weighted axial magnetic resonance images showing the foraminoplasty not violating the facet joint.



**Fig. 5** Pre- (left) and postoperative (right) T<sub>2</sub>-weighted sagittal magnetic resonance images showing foraminoplasty (arrow).



**Fig. 6** Left: Endoscopic photograph showing the exposed ruptured fragment. The undersurface of the facet (blue arrow) was removed by the endoscopic bone cutter and the ruptured disk fragment is stained blue. Right: Schematic drawing after removal of the ligamentum flavum illustrating the blue stained ruptured fragment (RF). FJ: facet joint.



**Fig. 7** Left: Endoscopic photograph showing the traversing nerve root. Right: Schematic drawing illustrating the traversing nerve root (TNR), disk space (DS), and annulus (An).

the herniated disk were constricted. After that, the herniated mass was removed with the endoscopic forceps. Finally, free movement of dural sac and epidural pulsation could be visualized by changing irrigation pressure; the decompressed traversing root and dural sac could be confirmed after the intradiscal and epidural dissection (Fig. 7). A subcutaneous suture was placed and a sterile strip was used. The narrow foramen was successfully decompressed and the result was confirmed by postoperative MR imaging (Figs. 4 and 5). Most patients showed no postoperative problems, and were discharged from the hospital within 24 hours.

**Results**

The mean preoperative VAS score for leg pain was  $7.4 \pm 3.0$  (range 0–10), whereas the mean ODI was  $55.5 \pm 21.7\%$  (range 22.2–97.7%). The average duration of symptoms was 7.4 months (range 5–13 months). At the last follow up, at least more than 28

months postoperatively, mean VAS score for leg pain was  $1.6 \pm 2.6$  (range 0–8), whereas the mean ODI was  $16.9 \pm 14.8\%$  (range 0–64%). The improvements in the VAS for leg pain and the ODI were both statistically significant ( $p < 0.001$ ).

Twenty-two patients showed excellent to good results at the last follow-up examination (Fig. 3). However, one patient had fair outcome and two patients had poor outcomes. The mean period before return to work was 7.2 weeks (range 2–24 weeks). One patient was converted by OLM due to incomplete decompression. After the revision surgery, the patient could maintain normal activities and returned to work 8 weeks after the surgery. On the other hand, another patient underwent OLM after recurrent disk herniation. The other patient received further physical therapy and repeated injection therapy. Postoperatively, two patients complained of transient dysesthesia, which was improved completely 6 weeks later. During the study, no patient showed neurological deficit or infection.

## Discussion

In contrast to other lumbar vertebral levels, the L5-S1 level presents unique anatomical limitations to the percutaneous transforaminal approach as follows: high iliac crest, ala, large facet joint, and narrow foramen. Analysis of the location of the extraforaminal lumbar nerve roots in relation to the intertransverse space by cadaveric dissection found that the L5-S1 level, due to lordotic curvature and the high iliac crest, creates difficulty in reaching the L5 nerve root and removing the extraforaminal disk herniation via the narrow intertransverse space.<sup>6)</sup> The extraforaminal lumbar nerve root passes across the disk, so extreme care is required to avoid nerve root injury. In addition, measurements showed increases in the extraforaminal nerve root angle and diameter, and the distance between the superior facet and lateral limit of the nerve root from cephalad to caudal. The height and width of the intertransverse space was greatest at the L3–4 level and smallest at the L5-S1 level. Another finding was that the incidence of injury to the lumbar nerve root should be minimized during the posterolateral approach.<sup>6)</sup> Therefore, most surgeons regard L5-S1 discectomy as a challenging procedure and fewer cases have been reported.<sup>1,9,11–14)</sup> The narrow foramen is likely to cause neural injury during the approach to the L5-S1 level, so PELD has not been considered desirable.<sup>1,4)</sup> Therefore, instead of performing conventional PELD, a posterior extrathecal needle approach was recommended to the L5-S1 disk space as an effective option for percutaneous laser disk

decompression, especially for patients with high iliac crests.<sup>5)</sup>

The interlaminar approach<sup>4)</sup> has been performed for lumbar disk herniation at L5-S1 with high iliac crest associated with wide interlaminar space and relatively small thecal sac, and transiliac PELD<sup>3)</sup> has been used for upmigrated foraminal disk herniation with high iliac crest, which is not accessible by conventional transforaminal PELD or interlaminar approach. This interlaminar technique can use either the axilla approach or the shoulder approach. The axilla approach targets the axilla of the S1 root. The shoulder approach is used if there is no safe area in the axilla region. These two approaches are compatible. However, the interlaminar approach has several disadvantages. For instance, the narrow interlaminar space can result in dysesthesia and pain, as well as requiring expensive surgical instruments. Open microdiscectomy should be considered if preoperative neuroimaging detects no safe spaces in either the shoulder or axilla regions.<sup>4)</sup>

Access through the foramen with a working cannula seems very difficult at the L5-S1 level by the conventional posterolateral approach because of the various anatomical challenges. Therefore, we performed ‘foraminoplasty’ to widen the foraminal space. The ‘foraminoplasty’ approach allows expansion of the foramen and ablation of contributory osteophytes, disk protrusion, and epidural fibrosis.<sup>1)</sup> We selected the bone cutter among the available surgical tools to expand the foraminal space, which has the best surgical results according to our experience. However, the choice of surgical tools for bone cutting remains controversial. Only a few surgeons use the bone cutter to undercut the superior facet.<sup>1,7,9,11–14,18,19)</sup> Previous studies only reported a laser beam as a surgical tool for undercutting the hypertrophic superior facet and targeted structures.<sup>1,9,11–13,19)</sup> Nevertheless, our experiences indicate that the bone cutter has very competitive advantages, such as enabling the surgeon to remove hardened bony osteophytes or hypertrophic superior facet that covers and obliterates the neural foramen.

Our present surgical results suggest that the ‘foraminoplasty’ approach has the following advantages. Neural injuries can be avoided, and postoperative foraminal stenosis can be prevented. We found that the working space was wider, which allowed treatment similarly to the epidural approach. During the ‘foraminoplasty’ ventral epidural approach, we expected considerable blood loss while removing the superior facet with the endoscopic bone cutter, since removal of the soft tissue around the foramen might lead to profuse blood loss by interrupting the venous sinus channel. However, since the en-

doscopy-bone cutter pushed the resected bony fragment into the location of the venous sinus channel, the sinus was naturally blocked inducing natural homeostasis.

Surgeons should be aware that understanding the exact anatomical conditions is the most important factor to obtain the best surgical results. Anatomically, L5-S1 presents rather different conditions compared to other levels, so could cause unpredicted intraoperative challenges in individual patients. We consider that surgeons cannot be too careful in selecting patients based on the best knowledge of the 'foraminoplastic' approach. Even experienced surgeons and well-selected patients must make compromises in the surgical results.

The 'foraminoplastic' ventral epidural approach is an effective surgical option even at the L5-S1 level in selected patients. Adequate working space must be obtained by undercutting the superior facet without neural injury. The 'foraminoplastic' ventral epidural approach is possible in patients with high iliac crest and narrow foramen, thus assuring rapid recovery.

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### References

- 1) Ahn Y, Lee SH, Park WM, Lee HY: Posterolateral percutaneous endoscopic lumbar foraminotomy for L5-S1 foraminal or lateral exit zone stenosis. Technical note. *J Neurosurg* 99(Suppl 3): 320-323, 2003
- 2) Ahn Y, Lee SH, Park WM, Lee HY, Shin SW, Kang HY: Percutaneous endoscopic lumbar discectomy for recurrent disc herniation: surgical technique, outcome, and prognostic factors of 43 consecutive cases. *Spine* 29: E326-E332, 2004
- 3) Choi G, Kim JS, Lokhande P, Lee SH: Percutaneous endoscopic lumbar discectomy by transiliac approach: a case report. *Spine* 34: E443-446, 2009
- 4) Choi G, Lee SH, Raiturker PP, Lee S, Chae YS: Percutaneous endoscopic interlaminar discectomy for intracanalicular disc herniations at L5-S1 using a rigid working channel endoscope. *Neurosurgery* 58(Suppl 1): ONS59-ONS68, 2006
- 5) Choy DS: The problem of the L5-S1 disc solved by needle entry with an extrathecal approach. *J Clin Laser Med Surg* 12: 321-324, 1994
- 6) Ebraheim NA, Xu R, Huntoon M, Yeasting RA: Location of the extraforaminal lumbar nerve roots. An anatomic study. *Clin Orthop Relat Res* 340: 230-235, 1997
- 7) Hafez MI, Zhou S, Coombs RR, McCarthy ID: The effect of irrigation on peak temperatures in nerve root, dura, and intervertebral disc during laser-assisted foraminoplasty. *Lasers Surg Med* 29: 33-37, 2001
- 8) Hermantin FU, Peters T, Quartararo L, Kambin P: A prospective, randomized study comparing the results of open discectomy with those of video-assisted arthroscopic microdiscectomy. *J Bone Joint Surg Am* 81: 958-965, 1999
- 9) Kambin P, Casey K, O'Brien E, Zhou L: Transforaminal arthroscopic decompression of lateral recess stenosis. *J Neurosurg* 84: 462-467, 1996
- 10) Kambin P, Gellman H: Percutaneous lateral discectomy of the lumbar spine: A preliminary report. *Clin Orthop Relat Res* 174: 127-132, 1983
- 11) Knight MT, Ellison DR, Goswami A, Hillier VF: Review of safety in endoscopic laser foraminoplasty for the management of back pain. *J Clin Laser Med Surg* 19: 147-157, 2001
- 12) Knight MT, Goswami A, Patko JT, Buxton N: Endoscopic foraminoplasty: a prospective study on 250 consecutive patients with independent evaluation. *J Clin Laser Med Surg* 19: 73-81, 2001
- 13) Knight MT, Vajda A, Jakab GV, Awan S: Endoscopic laser foraminoplasty on the lumbar spine—early experience. *Minim Invasive Neurosurg* 41: 5-9, 1998
- 14) Lew SM, Mehalic TF, Fagone KL: Transforaminal percutaneous endoscopic discectomy in the treatment of far-lateral and foraminal lumbar disc herniations. *J Neurosurg* 94(Suppl 2): 216-220, 2001
- 15) Mayer HM, Brock M: Percutaneous endoscopic lumbar discectomy (PELD). *Neurosurg Rev* 16: 115-120, 1993
- 16) Mirkovic SR, Schwartz DG, Glazier KD: Anatomic considerations in lumbar posterolateral percutaneous procedures. *Spine* 20: 1965-1971, 1995
- 17) Reulen HJ, Muller A, Ebeling U: Microsurgical anatomy of the lateral approach to extraforaminal lumbar disc herniations. *Neurosurgery* 39: 345-350, 1996
- 18) Yeung AT: The evolution of percutaneous spinal endoscopy and discectomy: state of the art. *Mt Sinai J Med* 67: 327-332, 2000
- 19) Yeung AT, Tsou PM: Posterolateral endoscopic excision for lumbar disc herniation: Surgical technique, outcome, and complications in 307 consecutive cases. *Spine* 27: 722-731, 2002

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