Transforaminal Percutaneous Endoscopic Discectomy in the Treatment of Foraminal and Extraforaminal Lumbar Disc Herniations

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Abstract: The objective of this study is to evaluate the efficacy of the endoscopic technique, as applied to patients with foraminal and extraforaminal disc herniations, and to report the outcome and complications. A retrospective analysis was performed of 35 consecutive cases of foraminal and extraforaminal lumbar disc herniation managed by posterolateral endoscopic discectomy. Pain was measured by means of the Visual Analog Score. Patient satisfaction was evaluated by the Macnab outcome criteria. The median follow-up period was 18 months (range 10 to 35 months). The mean Visual Analog Score improved from 8.6 before the surgery to 3.2 after the surgery. Overall, excellent or good outcomes were obtained in 30 (85.7%) of the 35 patients at the last follow-up examination, with both these outcomes showing statistically significant improvement ($P < 0.01$). There were no complications related to the surgery, nor was any spinal instability detected. Three patients (8.6%) experienced persistent radiculopathy and subsequently underwent open microdiscectomy at the same level. We concluded that transforaminal percutaneous endoscopic discectomy is safe and efficacious in the treatment of foraminal or extraforaminal disc herniations. However, proper patient selection is paramount to ensure a satisfactory outcome after decompression of foraminal and extraforaminal disc herniations.

Key Words: endoscopy, extraforaminal and foraminal disc, discectomy

(*J Spinal Disord Tech* 2006;19:338–343)

Foraminal and extraforaminal lumbar disc herniations have been reported to account for between 1% and 12% of all lumbar disc herniations.[1–3]

The foraminal zone refers to the area of the intervertebral canal beneath the pedicle and the pars interarticularis, while the extraforaminal zone, as defined by Kunogi and Hasue, lies outside the lateral border of the pedicle.[4]

Received for publication October 20, 2004; accepted October 31, 2005.
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Foraminal and extraforaminal disc herniations are generally found in older patients and were first described by Abdullah et al in 1974, with the L4-5 level being the most commonly affected.[1–3]

Different surgical approaches, including the midline and paraspinal approach, have been utilized to reach these foraminal and extraforaminal disc herniations.[1–17]

There have been recent improvements in the posterolateral endoscopic technique and its associated operating equipment. The development of the transforaminal, percutaneous endoscopic technique for the decompression of herniated lumbar discs represents an attempt to improve operative efficacy, reduce the postoperative pain, limit the length of hospitalization, reduce perineural fibrosis and minimize the development of instability.[18–25]

In the current study, we document the outcome for 35 patients with intraforaminal and extraforaminal herniated discs who were surgically treated with transforaminal percutaneous endoscopic lumbar discectomies, and we evaluate the efficacy and safety of this technique.

MATERIALS AND METHODS

Between January 2002 and December 2003, three hundred five patients underwent a transforaminal percutaneous endoscopic lumbar discectomy performed by the author (*Jee-Soo Jang*). This study represents a retrospective review of 35 (11.1%) among these patients, consisting of 20 women and 15 men, for whom a percutaneous transforaminal, posterolateral approach was used for the treatment of foraminal and extraforaminal disc herniations. The age of the patients ranged from 22 to 84 years (mean age, 61 years). The inclusion criteria were as follows: (a) unilateral radicular leg pain, single-level foraminal or extraforaminal lumbar disc herniation, as demonstrated on computed tomography (CT) scan and magnetic resonance imaging (MRI); (b) successful pain relief by diagnostic selective nerve root block; (c) failure of conservative therapies, including therapeutic selective nerve root block. The exclusion criteria were definite segmental instability, foraminal stenosis, spondylolytic spondylolisthesis, motor weakness, or previous lumbar surgery in the same region. All patients underwent immediate postoperative CT scan and MRI.

Preoperative Neuroimaging Evaluation

Neuroimaging studies were performed in all patients to confirm the diagnosis. Nonenhanced 3-mm slice CT scanning and MRI were conducted in all patients. These diagnostic investigations revealed disc herniations, either intraforaminal or extreme lateral, at the L5-S1 level in 3 patients (9%), at the L4-5 level in 20 patients (57%), at the L3-4 level in 10 patients (28%), and at the L2-3 level in 2 patients (6%). The herniated disc was located at an intraforaminal location in 9 cases. Disc herniation occurred exclusively at an extreme lateral location in 17 cases, while a simultaneous foraminal and extreme lateral location was documented in 9 patients (Table 1). In all the patients, the neuroimaging findings correlated with the neurological examination and selective nerve root block was performed at the compressed nerve, as demonstrated on CT scan and MRI for the purpose of diagnosis and conservative therapy.

Surgical Technique

Fluoroscopic monitoring in the antero-posterior and lateral projection was essential to ensure the correct placement of the instrumentation at each step. The patient was placed in the prone position, with the back mildly flexed, on top of a radiolucent table, and was kept conscious during the procedure to enable any changes in pain to be monitored. Therefore, anesthesia was limited to 1% local lidocaine infiltration, supplemented with conscious sedation. The skin entry point was determined on the preoperative CT scan or the axial view of the MRI. The exact location of this point was dictated by the size of the patient, the dimensions of the facet joints, and the desired location of the tip of the needle in the triangular working zone that is bounded superiorly and anteriorly by the nerve root, inferiorly by the transverse process, and medially by the superior facet.

The angle of insertion of the needle used for extraforaminal disc herniation should be stiffer than that used for foraminal disc herniation. The extraforaminal disc was located more laterally than the foraminal disc. Therefore, a more vertical approach for the working channel could make it easier to access the laterally located extraforaminal disc.

The correct position of the needle tip was confirmed using both anteroposterior and lateral projections. The needle was inserted parallel to the disc space, midway between the end plates. After the insertion of the needle, discography was performed using a contrast mixture consisting of 6 mL of telebrix and 1 mL of indigo carmine (which is a nontoxic marker dye that has no neurotoxicity) for the staining of the disc material. A guide-wire was inserted through the needle channel into the annulus, and a small stab incision was made at the entry site of the needle. After withdrawing the needle, a tapered cannulated obturator was slid over the guide-wire and advanced into the disc space. A beveled working cannula was introduced over the obturator, which was then removed, and the endoscope was inserted. Gentle tapping of the annulus with the spinal needle before performing the discectomy helped to confirm the absence of neural impingement. After confirming the position of the working cannula in the disc space, internal decompression of the disc was performed with pituitary forceps. After the internal decompression, the working cannula was pulled out from the disc space to the foramen (Fig. 1). Any epidural bleeding encountered was controlled by using a wide-sweep, radio frequency trigger-flex bipolar probe (Fig. 2). Foraminal decompression was performed by ablating the tip of the superior facet of the inferior vertebra and ligamentum flavum by using a Holmium yttrium-aluminum-garnet laser beam (Fig. 3).

In most cases of foraminal and extraforaminal disc herniation, the ruptured or protruding disc fragment is found to have slipped upward and migrated laterally. Consequently, the tip of the working cannular should be positioned in the cephalad and lateral direction (Fig. 4). The tip of the working cannula is not anchored inside the disc space anymore at this time. Therefore, the working cannula can be moved in all directions. From the endoscopic intraforaminal view, the surgeon was able to identify the superior facet and the exiting nerve root.

TABLE 1. Location of Foraminal and Extraforaminal Disc Herniations in 35 Cases

Level	Intraforaminal	Extraforaminal	Both	Total
L2–3	0	2	0	2
L3–4	3	4	3	10
L4–5	4	10	6	20
L5–S1	1	1	1	3
Total	8	17	9	35

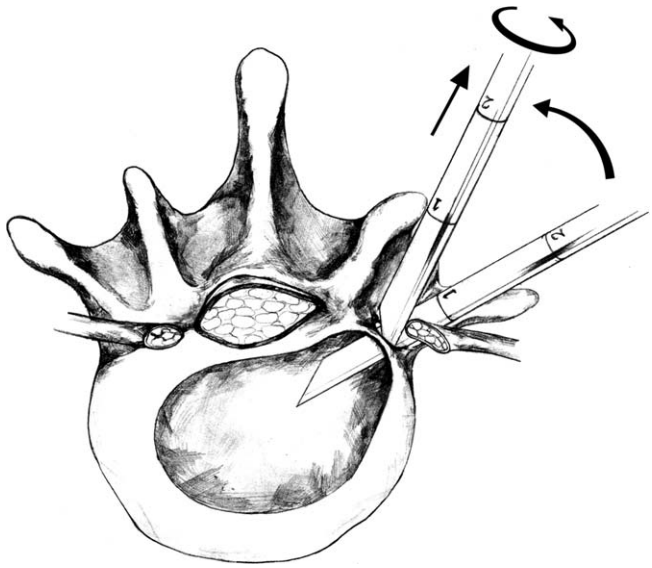

FIGURE 1. After internal decompression the working cannular was pulled out from the disc space to the foramen. When the tip of the working cannular is placed upon the disc surface, the angle of the working cannular should be changed to more acute for the removal of the foraminal or extraforaminal disc herniation.

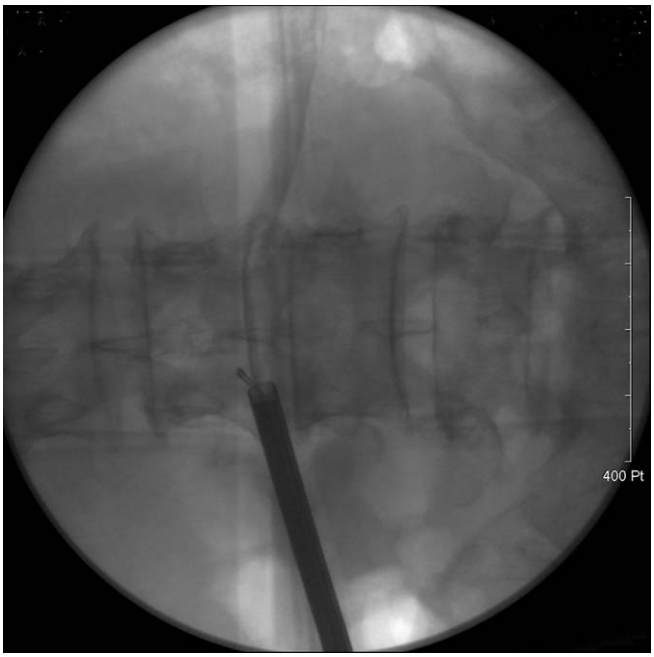

FIGURE 2. Any epidural bleeding encountered is controlled by using a radio frequency trigger-flex bipolar probe.

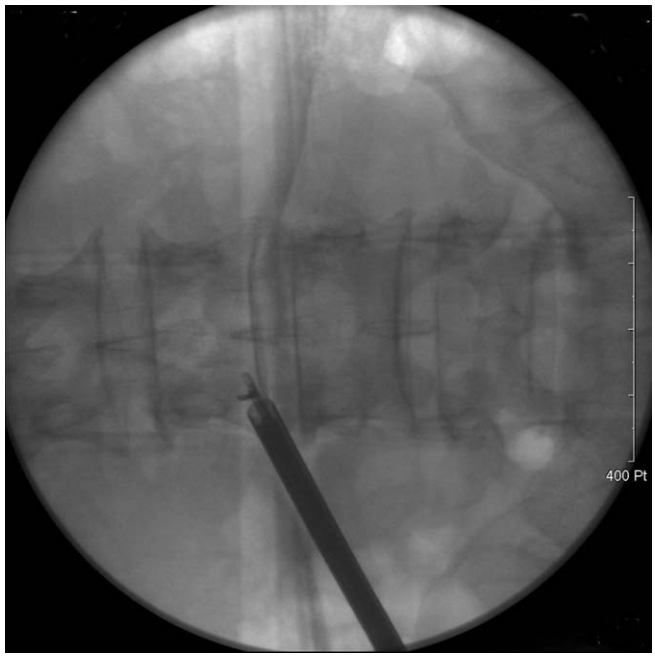

FIGURE 4. The tip of the working cannular should be positioned in the cephalad and in a lateral direction for the removal of the upward and laterally migrated disc fragment.

After confirming the exiting nerve root, the working cannular could be moved along the exiting nerve root to scrutinize and remove the disc fragment. By this technique, direct nerve root decompression was successfully performed by removing the free disc fragment. When all the disc material had been removed, the scope was withdrawn and a sterile dressing was applied. MRI was then conducted to confirm the removal of the disc fragment (Fig. 5).

Outcome Evaluation

The surgical outcomes were assessed using both the Macnab outcome criteria and the Visual Analog Score (VAS). The outcome measurements were assessed by applying the Macnab outcome criteria, which consider radicular pain, neurological deficits, and activity as the major variables (Table 2).[26] On the VAS, the patient indicates the intensity of the pain experienced on a typical day, by making a mark on a line graduated from 0 to 10, corresponding to the pain level. In the current study, the improvement in both the outcome measurements was found to be statistically significant ($P < 0.01$). The records for each patient were analyzed with respect to the clinical findings, radiological examination, operative procedure, and surgery-related complications, and the incidence of subsequent operations. The outcome data were primarily obtained by office visits and direct contact 6 weeks postoperatively. Thereafter, follow-up information was obtained by trained nurses via telephone interviews or hospital visits, at 3, 6, 12 and 24 months postoperatively.

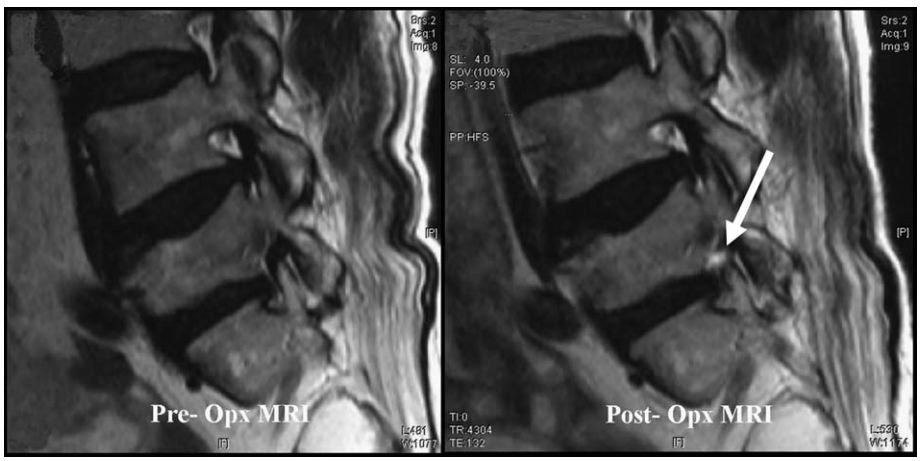

FIGURE 3. Foraminal decompression is performed by ablating the tip of the superior facet of the inferior vertebra and ligamentum flavum by using a Holmium yttrium–aluminum–garnet laser beam.

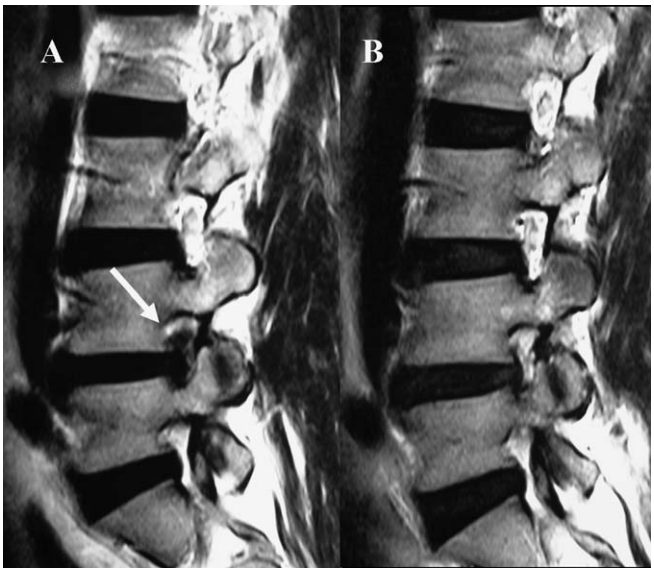

FIGURE 5. A, Preoperative sagittal MRI showing nerve compression by the up-migrated disc fragment. B, Postoperative sagittal MRI showing the nerve decompression obtained by removal of the disc fragment.

The data were collected by a registered nurse assisting the operating surgeon.

RESULTS

The operative time ranged from 40 to 60 minutes. During the procedure, we asked the patient if the leg pain was aggravated or not. Therefore, we did not have any cases of neural injuries during the procedures in this study. All the patients were discharged home within 24 hours. The mean follow-up period was 18 months (range 10 to 35 months).

In the immediate postoperative period, 6 patients (17%) developed burning dysesthesia in the sensory distribution of the operated nerve root. This pain was controlled by selective nerve root block and medication with carbamazepine postoperatively and usually resolved within 4 to 6 weeks. The mean preoperative and postoperative VAS scores were from 8.6 before the surgery to 3.2 after the surgery. These improvements were statistically significant ($P < 0.01$). Overall, excellent or good outcomes were obtained in 30 (85.7%) of the 35 patients as determined at the last follow-up examination according to the Macnab criteria.

One patient had postoperative back pain, but the leg pain was relieved.

In another patient the severity of the leg pain reduced; however, remnants of leg pain remained after the procedure. The leg pain was controlled by selective root block and analgesics. These 2 patients were not satisfied with the surgical results despite the improvement of their clinical symptoms. The outcomes of these patients were categorized as fair. Eight patients complained of remnant radiculopathy that was treated by selective nerve root block. Three (8.6%) of these 8 patients experienced persistent radiculopathy with poor outcome, and subsequently underwent open microdiscectomy via the lateral approach at the same level and on the same side. Under microscopy, the exiting nerve root was compressed by the narrowed foramen in all patients, and by a remnant disc fragment in 1 patient. After the surgery, the patients were relieved of leg pain. Two of the open microdiscectomies involved lumbar disc herniation at the L4-5 level. One of the open microdiscectomies involved lumbar disc herniation at the L5-S1 level.

TABLE 2. Macnab Criteria for the Classification of Outcome

Classification	Criteria
Excellent	No pain; no restriction of activity
Good	Occasional back pain, or leg pain of sufficient severity to interfere with the patient's ability to do normal work or his capacity to enjoy leisure hours
Fair	Improved function capacity, but handicapped by intermittent pain of sufficient severity to curtail or modify work or leisure activities
Poor	No improvement or no sufficient improvement to enable increase in activities; further operative intervention required

DISCUSSION

The clinical syndrome of foraminal or extraforaminal lumbar disc herniations and its surgical decompression through a posterior approach was first reported by Abdullah and colleagues.[1] These herniations have several specific clinical features, including in particular, severe radicular pain. The dorsal root ganglion has been reported to be one of the causative factors of severe radicular symptoms in patients with foraminal or extraforaminal disc herniations.[27,28] Patients with more cephalad far-lateral discs exhibit proximal hip pain radiating into the anterior thigh and knee. The radicular pain is aggravated by extension or lateral bending. Therefore, the patient often crouches to relieve the pain.

Herniations outside the neural foramen are often overlooked in high-resolution CT scan or MRI. Nonrecognition of this disease entity could result in the failure to properly diagnose the condition and offer surgical treatment for disabling and refractory radicular pain. High-resolution CT scan studies of lateral, foraminal, or extraforaminal herniation is dependent on the differential densities of the disc material, nerve root, epidural fat, and the thecal sac.[29] In this series, standard CT scan slices were used in all the patients to facilitate the diagnosis of the foraminal and extraforaminal disc herniations. Standard CT scan views can clearly demonstrate foraminal and extraforaminal disc herniations, by comparing them with views taken from the contralateral side.[29,30] In this series, MRI with a standard axial and parasagittal view was the diagnosis tool of choice for visualizing the foraminal and extraforaminal disc herniations. As with foraminal disc herniations, upward

migrated disc material is detected on the parasagittal view through the lateral exit zone. Extraforaminal disc herniation is detected on the axial view of the MRI. Coronal MRI may also be of value in diagnosing foraminal and extraforaminal disc herniations.[31]

Different surgical approaches have been utilized to reach foraminal and extraforaminal disc herniations. Conventional open surgery involving both midline and paramedian approaches has been performed to treat these lesions. Several authors have advocated the medial interlaminar approach.[1,3–5,8,9,12,13] However, because in most foraminal and extraforaminal disc herniations a free fragment has slipped upward and migrated laterally, this requires an important upward and lateral enlargement of the interlaminar fenestration. The removal of this important bone weakens the base of the articular process and may result in fracture, despite partial facetectomy.[15]

In an attempt to minimize the amount of bone resection but nevertheless reach the foraminal and extraforaminal space, several authors contributed to the development of a paramedian transmuscular approach which has been described previously by Wiltse et al.[6,10,14–17] With this technique, the dissection remains immediately lateral to the facet joint, and retraction is minimized. The use of a microsurgical technique greatly facilitates the dissection, when opening the transverse ligament and performing decompression of the neural structure. By using the paramedian transmuscular approach combined with microsurgical techniques, there is minimal resection of the bone and facet joint and little risk of injury to the neural structures. This approach can be easily combined with the interlaminar approach when facet hypertrophy or more medial pathological material is present.[7,11] The paramedian approach remains an excellent option, although it is not familiar and is not practiced by many spine surgeons.

Many authors have recently contributed to the development of the posterolateral percutaneous endoscopic technique for various lumbar disc diseases.[18–25] Kambin et al reported a success rate of 88.2% for arthroscopic microdiscectomy and this report included the treatment of foraminal and extraforaminal herniation.[21] Lew et al reported a success rate of 85% for transforaminal percutaneous endoscopic discectomy that was used to treat foraminal and extraforaminal lumbar disc herniation.[24]

When using the percutaneous techniques for treating foraminal and extraforaminal disc herniations, surgical access is gained via a 1-cm posterolateral incision, in which case the muscle fibers are not severed, but separated with the aid of a cannulated obturator, thus preventing denervation of the musculature and formation of scars. The advantages of this technique over conventional laminectomy and discectomy include low morbidity, reduced denervation of the musculature and reduced perineural fibrosis, preservation of spinal stability, and a more rapid recovery.[18–25]

A new technique and special equipment are needed for working in tight quarters. A Holmium YAG laser is normally used to ablate the hard-to-reach annulus fibrosus attachments, the ligamentum flavum and also the osteophytes when needed. The laser's unique ability to ablate bone and firm fibrous tissue is used to remove the tip from the superior facet of the inferior vertebra and also the deep surface from the same facet.[25] The bipolar radio frequency, flexible, trigger-flex probe has expanded the epidural boundaries of exploration. This device has good practical use in reaching out and coagulating bleeders in hard-to-reach places, including the epidural space, with little or no unintended collateral tissue injury.[25]

The success rate (good and excellent outcomes) of this study was 85.7%. These results compare favorably with the published outcomes for those patients with foraminal and extraforaminal disc herniations that were treated by the conventional surgical approaches.[5–8,11,12,21,22] However, a main limitation to this procedure is its inability to successfully treat foraminal or extraforaminal nerve root compression at the L5-S1 level. The L5-S1 level may pose some technical difficulties because of the possible proximity of the iliac crest or prominent alae sacralis, which may make it impossible to obtain an oblique view into the depth of the lateral interpedicular compartment. A paramuscular approach combined with a more extensive far-lateral bone drilling of the sacral structures may be appropriate in these difficult anatomical conditions. Ahn et al[32] have demonstrated the clinical efficacy of the posterolateral percutaneous endoscopic lumbar foraminotomy for L5-S1 foraminal or extraforaminal exit zone stenosis. However, the unique anatomical condition at L5-S1, such as the proximity of the iliac crest, sacrum and L5 transverse process, acts as an obstacle, with the result that access at this level is considered too difficult. Moreover, in many cases, foraminal or extraforaminal disc herniations are combined with stenosis in this region. Patients with foraminal and extraforaminal disc herniations combined with stenosis at L5-S1 are not likely to benefit from this operative procedure. Therefore, endoscopic foraminal or extraforaminal decompression would be prudent at L5-S1 level. In this study, we performed posterolateral endoscopic discectomy for foraminal or extraforaminal disc herniation at L5-S1 in the case of a tall disc without stenosis. The angle of the working cannular for the L5-S1 level should be more acute than that for the other levels to avoid anatomical obstacles such as the high iliac crest.

Six patients (17%) developed burning dysesthesia in the sensory distribution of the operated nerve root. This pain was controlled by selective nerve root block and medication with carbamazepine postoperatively and was usually resolved within 4 to 6 weeks. This transient neuropathic pain was common and was theorized to be caused by the manipulation of the dorsal root ganglion during surgery.[14] So far, we have not encountered any vascular complications after this operative procedure. Although the outcome is encouraging in this limited group of 35 patients who underwent endoscopic decompression of foraminal and extraforaminal lumbar disc

herniations, a large number of patients and longer follow-up period are needed to confirm these early results.

CONCLUSION

In our limited experience, the posterolateral endoscopic approach to foraminal and extraforaminal lumbar disc herniations for the decompression of the exiting root contributes a minimally invasive procedure that seems to be safe and effective. Proper patient selection is paramount to ensure a satisfactory outcome after decompression of foraminal and extraforaminal disc herniations.

REFERENCES

1. Abdullah AF, Ditto EW III, Byrd EB. Extreme-lateral lumbar disc herniations. Clinical syndrome and special problems of diagnosis. *J Neurosurg*. 1974;41:229–234.
2. O'Hara LJ, Marshall RW. Far lateral lumbar disc herniation. The key to the intertransverse approach. *J Bone Joint Surg Br*. 1997;79: 943–947.
3. Siebner HR, Faulhauer K. Frequency and specific surgical management of far lateral lumbar disc herniations. *Acta Neurochir*. 1990; 105:124–131.
4. Kunogi J, Hasue M. Diagnosis and operative treatment of intraforaminal and extraforaminal nerve root compression. *Spine*. 1991;16:1312–1320.
5. Abdullah AF, Wolber PG, Warfield JR. Surgical management of extreme lateral lumbar disc herniations: Review of 138 cases. *Neurosurgery*. 1988;22:648–653.
6. Darden BV II, Wade JF, Alexander R. Far lateral disc herniations treated by microscopic fragment excision. Techniques and results. *Spine*. 1995;20:1500–1505.
7. Donaldson WF III, Star MJ, Thorne RP. Surgical treatment for the far lateral herniated lumbar disc. *Spine*. 1993;18:1263–1267.
8. Epstein NE. Evaluation of varied surgical approaches used in the management of 170 far-lateral lumbar disc herniations: Indications and results. *J Neurosurg*. 1995;83:648–656.
9. Epstein NE. Different surgical approaches to far lateral lumbar disc herniations. *J Spinal Disord*. 1995;8:383–394.
10. Fankhauser H, de Tribolet N. Extreme lateral lumbar disc herniation. *Br J Neurosurg*. 1987;1:111–129.
11. Faust SE, Ducker TB, VanHassent JA. Lateral lumbar disc herniations. *J Spinal Disord*. 1992;5:97–103.
12. Garrido E, Connaughton PN. Unilateral facetectomy approach for lateral lumbar disc herniation. *J Neurosurg*. 1991;74:754–756.
13. Jackson RP, Glah JJ. Foraminal and extraforaminal lumbar disc herniation: Diagnosis and treatment. *Spine*. 1987;12:577–585.
14. Maroon JC, Kopitnik TA, Schulhof LA. Diagnosis and microsurgical approach to far-lateral disc herniation in the lumbar spine. *J Neurosurg*. 1990;72:378–382.
15. Porchet F, Bornand AC, de Tribolet N. Long-term follow-up of patients surgically treated by the far-lateral approach for foraminal and extraforaminal lumbar disc herniations. *J Neurosurg (Spine 1)*. 1999;90:59–66.
16. Reulen H, Pfaundler S, Ebeling U. The lateral approach to the "extracanalicular" lumbar disc herniation: a technical note. *Acta Neurochir*. 1987;84:64–67.
17. Wiltse LL, Spencer CW. New uses and refinements of the paraspinal approach to the lumbar spine. *Spine*. 1988;13:696–706.
18. Ditsworth DA. Endoscopic transforaminal lumbar discectomy and reconfiguration: A postero-lateral approach into the spinal canal. *Surg Neurol*. 1998;49:588–598.
19. Kambin P, Casey K, O'Brien E, et al. Transforaminal arthroscopic decompression of lateral recess stenosis. *J Neurosurg*. 1996;84: 462–467.
20. Kambin P, Gellman H. Percutaneous lateral discectomy of the lumbar spine: A preliminary report. *Clin Orthop*. 1983;174: 127–132.
21. Kambin P, O'Brien E, Zhou L, et al. Arthroscopic microdiscectomy and selective fragmentectomy. *Clin Orthop*. 1998;347:150–67.
22. Kambin P, Sampson S. Posterolateral percutaneous suction-excision of herniated lumbar intervertebral discs: Report of interim results. *Clin Orthop*. 1986;207:37–43.
23. Kambin P, Schaffer JL. Percutaneous lumbar discectomy: Review of 100 patients and current practice. *Clin Orthop*. 1989;238: 24–34.
24. Lew SM, Mehalic TF, Fagone KL. Transforaminal percutaneous endoscopic discectomy in the treatment of far-lateral and foraminal lumbar disc herniations. *J Neurosurg (Spine 2)*. 2001;94: 216–220.
25. Yeung AT, Tsou PM. Posterolateral endoscopic excision for lumbar disc herniation: Surgical technique, outcome, and complication in 307 consecutive cases. *Spine*. 2002;27:722–731.
26. Macnab I. Negative disc exploration. An analysis of the causes of nerve-root involvement in sixty-eight patients. *J Bone Joint Surg AM*. 1971;53:891–903.
27. Kikuchi S, Sato H, Konno S, et al. Anatomic and radiographic study of dorsal root ganglia. *Spine*. 1994;19:6–11.
28. Vanderlinden RG. Subarticular entrapment of the dorsal root ganglion as a cause of sciatic pain. *Spine*. 1984;9:19–22.
29. Williams AL, Haughton VM, Daniels DL, et al. CT recognition of lateral lumbar disc herniatin. *AJNR Am J Neuroradiol*. 1982; 3:211–213.
30. Godersky JC, Erickson DL, Seljeskog EL. Extreme lateral lumbar disc herniations: Diagnosis by computed tomographic scanning. *Neurosurgery*. 1984;14:549–552.
31. Hashimoto M, Watanabe O, Hirano H. Extraforaminal stenosis in the lumbosacral spine. Efficacy of MR imaging in the coronal plane. *Acta Radiol*. 1996;37:610–613.
32. Ahn Y, Lee SH, Park WM, et al. Posterolateral percutaneous endoscopic lumbar foraminotomy for L5-S1 foraminal or lateral exit zone stenosis. *J Neurosurg (Spine 3)*. 2003;99:320–323.